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GLOBALIZATION, TRADE & WAGES: WHAT DOES HISTORY TELL US ABOUT CHINA?

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ABSTRACT

Chinese imports and exports grew rapidly during the first three decades of the twentieth century as China opened up to global trade. Using a new data set on the factor-intensity of traded goods at the industry level, we show that Chinese exports became more unskilled-intensive and imports became more skill-intensive during these three decades. The exogenous shock of World War I dramatically raised the price of Chinese exports, increased the demand for Chinese goods overseas, and increased the demand for unskilled workers producing these goods. These trends continued even after the war ended. We show that the timing of the rise in export prices is consistent with the observed decline in the skill premium in China. The skill-unskilled wage ratio flattened out during the 1910s and then fell by eight percent during the 1920s. We simulate the price shock of World War I using a general equilibrium factor-endowments model of trade and find evidence consistent with the observed fall in the skill premium in China during the 1920s.

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One of the most contentious issues with respect to the global growth in trade is its effects on wages. Much of the debate has focused on how the expansion in trade between developing and developed countries affects the wages in the United States and Europe. The logic of trade theories such as the Heckscher-Ohlin-Vanek model and Stolper-Samuelson suggest that an expansion of trade will raise the wages of skilled workers and lower those of unskilled workers in developed countries if they are relatively well endowed with skilled labor. This has led some commentators to link the growing wage inequality within the U.S. to trade with the rest of world; even more specifically, some have suggested that as U.S. trade with China grows, wages for unskilled workers in the U.S. will fall in response.

An equally interesting question is how the global trade boom has altered wages in developing countries. For example, factor endowments also predict that the skill premium should be falling in rapidly developing countries like China where the stock of unskilled workers is large relative to developing countries. Using city-level data, Wei and Wu (2001) find evidence that inequality has fallen within China, and that the decline in rural-urban inequality have been most pronounced in areas that increased their openness (trade-GDP ratios). On the other hand, other empirical studies suggest that globalization has likely increased inequality in developing countries in the last three decades, although these findings depend on country-specific and time-specific factors.[1] For example, Wan, Lu, and Chen (2007) present evidence that increased FDI and trade have widened inequality within China more recently.

Determining the impact of the current trade boom on wages in developing and developed countries is complicated since trade has become more complicated than what is typically described in factor endowments models, whose origins are at least 90 years old. Intra-industry trade, outsourcing, offshoring, and multinationals complicate the testing of their theoretical predictions. More generally,

[1] For a survey, see Goldberg and Pacvcnik (2007). For articles on the effects of trade on skill premia in specific countries see, for example, Robbins (1996), Beyer, Rojas, and Vergara (1999), Gasparini (2003), Hanson (2004), and Robertson (2000, 2004).

confounding influences make the task of causal inference extremely challenging for studies examining current trade flows. For example, in thinking about the impact of expanding trade on the wage premium in developed countries today, empirical researchers may also need to account for declining union power, falling minimum wages, increased rates of immigration of unskilled workers, and greater skill-biased technological change. Similarly, analyses that focus on the impact of trade on wages in developing countries, like China, also face an array of challenging empirical issues that make identification difficult, including assessing the impacts of technological change, foreign direct investment, and state intervention on factor prices.

A number of scholars have suggested that the late nineteenth and early twentieth centuries may be better periods for testing the empirical predictions of factor endowments models. Estevadeordal and Taylor (2002) argue that low barriers to trade (especially in simple manufactured goods and agriculture), more skewed factor endowments, less trade in differentiated products and services, and minimal intra-industry trade are some characteristics of the first era of globalization that may make it a good laboratory for testing this class of models. O'Rourke and Williamson (1994, 1996, 1999) have provided empirical evidence of factor price convergence and other predictions of these models during the great expansion of trade in the late nineteenth century.

In this paper, we use the lens of history to better understand how a rapid expansion in trade affects the skill premium for a developing country. In particular, we ask how the skill premium in China responded to an earlier era of globalization and explosive growth in trade. We assemble new data on Chinese trade and wages for the period from 1903 to 1928 and use the exogenous shock of World War I to shed light on this question.

During the first three decades of the twentieth century, China experienced a tremendous growth in trade with the rest of the world. The nominal value of exports sextupled and imports rose roughly by the same amount (Figure 1). Although China had been forcibly opened to trade in the 1840s, the scale of trade was quite small until the Treaty of Shimonoseki was signed and an era of conflict with foreign powers concluded with Chinese supplication in the Boxer Uprising (1899-1901). The beginning of our sample period hence corresponds to a period of less conflict with foreign powers and China's entry into the global trade boom of the late nineteenth and early twentieth centuries. Like the current period of globalization, China's economy dramatically opened up to world trade: total trade as a share of GDP almost tripled during our sample period, an increase that is roughly comparable what China has experienced since 1978. With respect to the effects that trade had on wages, the most important change may have occurred in response to World War I – an event that altered global trade patterns and had lasting effects on Chinese trade. We show that the price of Chinese exports rose, leading to a surge in Chinese exports. Wages and employment rose for unskilled workers, which were utilized intensively in the production of Chinese exports.

We marshal new data on the factor content of Chinese trade to show that China's export boom in the first three decades was characterized by a rapid expansion in the production and sale of unskilled-intensive products to the rest of the world. In the second decade of the twentieth century, China's growth in exports of unskilled-intensive manufactures, mining, and agricultural products received an additional boost in demand from World War I. Whereas the war disrupted trade in many other parts of the world, it caused an expansion in Chinese exports, creating new markets for Chinese goods that had previously been served by producers in belligerent countries.

Employing unit value data from Chinese trade statistics, we show that the prices of key exports rose rapidly in response to the exogenous shock of World War I and continued to rise even after hostilities ended. Exports continued their upward trajectory as China's products were integrated into the global trade network.

Using new data on wages for unskilled and skilled workers, we argue that the growth in Chinese trade and the price shock of World War I largely account for the flattening out of the skill premium in the 1910s and the subsequent 8 percent fall in the skill premium between 1920 and 1928 (Figure 2). We develop a general equilibrium model of trade (based on factor endowments) and show how a price shock affects the skill premium. We then simulate the model and compare the results to the observed data on changes in the skill premium. We find that our model can simulate the decline in the skill premium once a shock is taken into account.

In the next section, we provide some historical background on the growth in Chinese trade during the first three decades of the twentieth century. Section III describes how we employ the theoretical predictions from factor endowments models to conduct a factor content analysis of Chinese trade. Section IV describes our new trade database assembled from the publications of the Chinese Maritime Customs Service and our methodology for estimating the factor content of trade. Section V assesses the relationship between factor content and export growth, calculates the change in export prices, and relates our trade data to changes in the skill premium in China during the first three decades of the twentieth century. Section VI presents a general equilibrium model of trade, simulates a price shock, and compares the results from the model to observed changes in the skill premium. The final section discusses the implications of our findings and concludes.

II. China's First Twentieth-Century Trade Boom

The first three decades of the twentieth century mark the period when China's trade with the rest of the world expanded significantly. Until the 1840s, China was largely a closed, agrarian economy; however, pressure from Great Britain and other foreign powers led China to open its economy to international trade. The 1842 Treaty of Nanking permitted foreigners to trade with the Chinese in five ports and stipulated a general five percent ad valorem tariff on almost all goods leaving and entering China. Over the subsequent sixty years, China saw a gradual opening up of trade as China signed treaties with foreign powers and additional ports were allowed to transact with foreigners.[2]

China's defeat in the Sino-Japanese war in 1895 ushered in further changes to Chinese trade and production. The Treaty of Shimonoseki allowed Japanese businesses to invest directly in China and produce goods and services that could be sold abroad as well as within China. Soon after the treaty was

[2] During this period, the largest import commodities were opium, cotton textiles, and petroleum products (kerosene, gasoline, etc.). Major exports were tea and silk.

signed, this privilege was extended to other foreign nations via most-favored-nation agreements. Foreign capital financed railroad, telecommunications, and shipping enterprises and spurred industrialization.

By the early twentieth century, the number of cities open to trade had climbed to 48 cities. As ports opened up and foreigners were allowed to invest and trade, China transitioned from a closed to an open economy. With no notable trade policy restrictions in place, China then experienced a sustained growth in international trade (Figure 1). Cheng (1956) estimates that between 1900 and 1913 the total value of trade grew twice as much as it had between 1868 and 1900. In the first 13 years of the twentieth century, the value of foreign exports nearly tripled, imports almost quadrupled, and the annual growth rate of trade averaged 7.4 percent. China's trade growth was faster than the world average in the first three decades of the twentieth century: its share of world trade increased from 1.5 percent around 1898 to 3.44 percent by 1928. By the early twentieth century, the Chinese economy was exploiting its comparative advantage in unskilled manufactures. Indicative of this growth was trade in cotton textiles, which became one of the fastest growing industries over the subsequent decades.

As we emphasize throughout this paper, World War I had transformative effects on the Chinese economy. It disrupted trade in other parts of the world and redirected it in the ways that directly benefited China, including a large increase in demand for its exports. Although China did not experience a dramatic acceleration in the growth rate of exports during World War I, this fact disguises several important effects the war had on Chinese exports and wages. Many countries experienced a contraction in trade during World War I (Glick and Taylor, 2001). Trade growth for China, on the other hand, was superior to the average country during this period. Imports were disrupted throughout World War I, but exports were only temporarily affected. After declining for one year, exports resumed their upward trajectory. Even during the war, they continued to grow at trend rather than below trend (Figure 1). In the ten years from 1917 to 1927, they grew at 7 percent annually. Just as important, the price of its exports began to rise during the war and continued an upward trajectory through the 1920s. Chinese exports to countries like the United States and Japan increased rapidly. The war redirected trade between other countries to China, and allowed it to expand production and further specialize according to comparative advantage. Most of

China's top exports (coal, minerals and mineral products, raw cotton and cotton textiles, bristle, and edible oils) received a considerable boost from World War I; moreover, demand from the rest of the world did not subside after the war ended (see Table 1). For example, trade records indicate that domestic yarn firms (cotton textiles) started to export in 1913, and by the mid 1920s, had largely displaced imports (Figure 3). Bristle (one of China's top 10 exports) was used to make brushes for machines, guns, and cannons; by 1930, China was supplying 90% of the world's bristle (You, 1990). Another top 10 export, edible oil, also received a considerable boost from World War I. After the outbreak of war, the oil-pressing industry in Europe, switched to the production of military-related products, leaving a huge gap in demand for edible oil in these countries. China filled this gap by dramatically increasing its exports to European belligerent countries.

III. Theoretical Framework

To formulate testable predictions of the effects of this trade boom on wages and (in Section VI) simulate the effects of a price shock on Chinese trade, we draw on insights from factor endowments models of trade. The Heckscher-Ohlin-Vanek (HOV) model predicts that when an economy that is relatively well endowed with unskilled labor opens up to foreign trade, it will specialize in producing unskilled labor intensive products for export. According to the Stolper-Samuelson theorem (SS), an increase in export prices will lead to an expansion in trade expands, and wages for unskilled workers will rise relative to those of skilled workers. Although HOV models and their related theorems often abstract from reality in their parsimony (two countries, two goods, two factors) and in their theoretical assumptions (constant returns to scale, perfect competition, identical production technologies, free mobility of goods, etc.), they are nevertheless useful for framing how trade based on comparative advantage affects factor prices within countries and for drawing attention to the winners and losers in trade. For example, policymakers have used the simple predictions of the 2x2x2 version of the models and the Stolper Samueson theorem to explain how increased trade and globalization is impacting wages. They also have been used by economists to consider the extent to which trade is driving increased wage inequality in the U.S. (Revenga, 1992; Lawrence and Slaughter, 1993; Leamer, 1988), and similarly, in predicting the consequences that China's expanding bilateral trade with the U.S. will have on U.S. wages (Krugman, 2008; Lawrence, 2008).

Despite their theoretical elegance, testing the predictions of the Stolper-Samuelson theorem is challenging.[3] Empirical researchers often restrict their attention to simple versions of factor content models so that they retain clearer theoretical predictions and avoid issues such as factor substitutability. There are nevertheless identification issues that make estimating the effects of trade on wages using modern data extremely challenging. Skill premiums today may be driven by a variety of factors that are difficult to disentangle, including technology, migration, and institutional changes in labor markets.

On the other hand, there are several reasons why factor endowments models may have more power in explaining the effect that trade has on wages in historical periods including our study of China during the first three decades of the twentieth century.[4] First, bulky standardized commodities, such as wheat and meat, and simple manufactures, like cotton goods, were the basis for the global growth in trade in the late-nineteenth and early-twentieth centuries (Findlay and O'Rourke, 2003). In contrast to the differentiated trade in goods and services today, differences in factor endowments may be sufficient for explaining the movement of raw materials and simple manufactures across national boarders (i.e., it may be unnecessary to appeal to newer trade models emphasizing product differentiation or the within-industry effects, such as Melitz (2003)). Second, there were fewer tariff and non-tariff barriers to trade, especially with respect to agricultural goods and low-skilled manufactured goods – two important areas of export for China during our sample period (Estevadeordal and Taylor, 2002).[5]

[3] An exception in the historical literature is O'Rourke, Taylor, and Williamson (1996), which examines the relationship between commodity and factor price convergence across a panel of eleven countries.

[4] For a review of factors driving skill premium today in developing countries, see Goldberg and Pavcnik (2007). As noted here, there are likely large differences in how trade operated in the earlier period of globalization in comparison to today.

[5] Much of the literature on the recent period of globalization has used evidence from changes in trade policy (i.e., tariff liberalization) to understand the impact of trade on wage inequality; however, since trade policy is the outcome of politics, it is an endogenous variable. Several recent studies have exploited additional cross-sectional (industry) and time variation in the data in order to deal with issues of causality (Hanson, 2007; Wei and Wu, 2001; Topalova, 2004; Goldberg and Pavcnik, 2005.) In this paper, we exploit an alternative source of exogenous variation to identify the impact of trade on wages – World War I – which we argue is an exogenous shock for Chinese trade.

Third, the effects of technological change operated differently on developing countries' skill premia, like China's, during the first global trade boom. In contrast to today, when we observe a considerable amount of skill-biased technological change, technological innovations in China in this earlier era were more of a complement to than a substitute for unskilled workers in the production process.[6] For example, in a fast-growing Chinese export sector like cotton textiles, the introduction of new machinery (ring spinning), which improved labor productivity, did not displace the demand for unskilled labor in this industry (Zhao and Chen, 1997).[7] By contrast, the use of primarily uneducated females grew rapidly in this industry. Government estimates suggest that, between 1912 and 1920, employment in cotton textiles in China grew by 32%, from 228,497 to 301,544, almost all of which was an expansion in unskilled labor (Ministry of Agriculture and Commerce, 1928, pp. 9-11). We would be the first to acknowledge that if technological change is complementary to unskilled labor, then some of the observed decline in the skill premium may be due to changes in technology.[8] It should be emphasized, however, that the vast majority of China's exports during the first three decades (in particular, agriculture, handicraft industries, and mining) experienced little technological progress during our sample period (Wang, 1998; Saxonhouse and Wright, 1984). For example, bristle, one of the leading exports in the first three decades of the twentieth century, was a typical labor-intensive handicraft; most workers employed in its production were uneducated and from low-income peasant families (You, 1990). Many of the other leading exports in our sample were agricultural and mining products, and the production of these products was unskilled intensive. It thus seems unlikely that technological change was the principal force that

[6] They were often embodied in machines that could be imported from other countries. Indeed, this may have been the motivation for H-O to assume that the same technology existed for two countries in their model of trade. Since transport costs fell dramatically during the era in which they wrote (and during part of our sample period), it would have seemed unrealistic to assume that countries couldn't simply have imported technology (embodied in machines) from other countries (Feenstra and Taylor, 2008).

[7] Chinese cotton textile factories imported ring-spinning technology from more industrialized countries, which used unskilled labor more intensively than the older technology of mule spinning. The type of technology employed also depended on the quality of cotton used in production. (Saxonhouse and Wright, 1984, 1987).

[8] If skill-biased technological change is concentrated in low-skilled sectors, then it could generate a decline in the skill premium (Leamer, 1984), which would be indistinguishable from a fall in the skill premium induced by a trade shock.

drove the precipitous decline in the skill premium. As a consequence, we will focus our attention on accounting for the effects arising from differences in factor endowments rather than technology.

Fourth, the growth in the stock of educated workers in China during the first three decades of the twentieth century was likely too small to alter the skill premium significantly. Enrollment rates in secondary schools rose late in the period and the stock of these newly educated workers was likely too small to have much of an effect on the wages of skilled workers (Xiong, 1990). And as noted above, unlike today, there appears to have been no surge in demand for skilled workers during this earlier era of globalization so that skill complementarity is less likely to explain the movements in skill premium in China.[9]

Fifth, although workers departed Europe in large numbers and went to the Americas during the nineteenth and early twentieth centuries, China's participation in this wave of global migration was much smaller. Roughly ten million Chinese emigrated between 1840 and 1920, which would translate into an average of a little less than one hundred thousand per year (Ge, Cao, and Wu, 1993, pp.485-6). In relation to the total population of China, roughly 400 million during our sample period, the emigration would have had a negligible effect on wages in China. Hence, it seems reasonable to assume that the effects of emigration on the wages of unskilled workers during our sample period is likely much more muted than in developing countries today.

Sixth, after 1894, foreign direct investment was permitted in China. Scholarship suggests that FDI may have served as a catalyst for China's industrialization. It was most concentrated in the parts of the manufacturing industry that had a greater reliance on advanced machinery. Overall, the total increase in foreign capital flows during our sample period was small and the rate of growth in FDI was fairly steady throughout the first three decades of the twentieth century (Hou, 1965). It exhibits no break or surge around World War I. FDI's effects on the skill premium are ambiguous: it may have increased the

[9] This is a notable difference from what is observed in developing countries today, like Argentina, Brazil, Mexico, Chile, Colombia, Hong Kong, and India, where the share of skilled workers within industries has increased dramatically over the past two decades (Robbins (1996), Sanchez-Paramo and Schady (2003), Attanasio and Szekely (2000), Blom, Goldberg, Pavcnik and Schady (2004), Hsieh and Woo (2005), and Kijima (2006).

demand for skilled workers as it has today or, as in the case of the role of technology in early-twentieth-century China, been complementary to unskilled labor.[10]

Seventh, unlike today, when institutions such as unions and minimum or state wages can impact observed wage rates, there is no evidence that the Chinese labor market faced significant regulation; hence the skill premium was not likely influenced by labor market institutions during the first three decades of the twentieth century. Finally, trade in intermediate products (i.e. outsourcing, offshoring, and "global product sharing") was insignificant in the earlier era of globalization.

IV. Data and Measurement of the Factor Content of Chinese Trade

We now examine how the Chinese trade boom of the first three decades of the twentieth century affected the skill premium in China. Figure 2 shows that the skill premium rose during the first decade of the twentieth century (when trade expanded, but export prices were relatively constant), but then flattened out and declined as export prices rose and the export boom continued virtually uninterrupted until 1929. Although the time series graph is broadly consistent with the view that the rapid growth in trade may have impacted the wages of skilled and unskilled workers in China, we subject this hypothesis to more scrutiny by considering whether the factor content of Chinese trade is consistent with the predictions of factor endowments models.

Factor endowment models in the spirit of HOV-SS predict that, as China opened up to trade with the rest of the world and received a boost when export prices rose (beginning around World War I), exports of goods that use relatively more unskilled labor (the abundant factor in China in comparison to skilled labor) in the production process will increase. The demand for unskilled labor will rise as the economy exports more. China will also begin to import more goods that are produced with relatively more skilled labor, thus reducing the domestic demand for skilled labor. As long as the supply curves for labor are not perfectly elastic, the shifts in demand for skilled and unskilled workers will cause the wages

[10] Stolper-Samuelson effects assume that labor and capital are mobile within a country, but immobile across borders. However, if we allow for FDI, Rybczinski's Theorem suggests no long-run impact on factor prices.

of skilled workers to fall relative to unskilled workers. Hence, factor endowment models predict that China's trade boom will cause the skill premium to fall.

A. Data

To examine the factor content of Chinese trade, we assemble new detailed estimates of exports and imports at the industry level from China Maritime Customs' (hereafter "CMC") trade publications. CMC was likely the only bureaucratic organization in China that operated without interruption (due to wars or funding shortages) from 1858 to 1949. Although it reported to the Chinese government, its top administration as well as mid-level managers and technocrats were largely foreigners – initially British citizens, but later on also Japanese and Americans. CMC's primary tasks were collecting customs revenue and recording and publishing data on foreign trade; however, it eventually expanded its operations to include collecting revenues from domestic trade, administering the postal system, developing inland and coastal waterways, and representing China at international fairs. CMC's geographical reach grew from just fourteen stations in the 1860s to nearly fifty during the 1920s, covering not only the coastal regions but also inland cities.

CMC published 160 volumes of detailed trade statistics, which span roughly 90 years of commercial transactions (1858-1949). We collected our new trade database using these publications, which are located in archives in Nanjing. CMC collected its data at the port level. Their records included information on the quantities and the values of all commodities passing through each treaty port. When aggregated, they also provide a detailed picture of China's trade with the rest of the world. In comparison to other economic or demographic data on China during this period, the quality and detail of the CMC trade data is exceptional and rivals the trade publications of the advanced nations of the late nineteenth century.[11]

[11] Trade statistics report types and destinations of trade, so that we are able to ensure that trade is not double counted. Values of export are F.O.B and values of imports are C.I.F.

Since CMC trade statistics were primarily published at the port level, the units of measurement and currency sometimes varied across ports and over time. We therefore standardized the measurement and currency units and then aggregated the product-level data to the national level.

B. Measurement

To assess the influence of the expansion in trade on the skill premium in China, we examine the factor content of Chinese exports. We keep our factor content analysis simple and consider differences in production based only on labor characteristics – whether workers were skilled or unskilled. Although this is clearly a simplification, it enables us to take advantage of our detailed trade data and new estimates of Chinese wages from Yan (2008) to further our understanding of the effects of trade and openness during a period of Chinese history when little information on other firm or industry characteristics exists.

After creating a database of quantities and values of all the traded commodities using the CMC trade publications, we classified exports and imports based on economic activity and skill intensity. To do this, we first selected a standard classification system so that we could systemize the aggregates of economic activity and measure factor content by "industry group." This is especially important because our database covers Chinese trade for all the treaty ports over three decades, the nomenclature of traded goods sometimes changed, and the individual customhouses sometimes collected trade statistics using their own naming systems.

Since the Standard Industrial Classification System (SIC) was not adopted in major industrial surveys or censuses, it has limited usefulness for the wide variety of commodities in our Chinese trade data. Instead, we use the Index of Occupations and Industries from the 1950 U.S. Census of Population ("IND1950"). The basic content of the occupational and industrial classification was largely derived from earlier censuses, in particular, the 1940 Census. Since IND1950 is somewhat retrospective in design, it provides a consistent set of industry codes that is broad enough to capture the trade being conducted by China between 1903 and 1928.

Next, we classified industries according to skill intensity. Since there is no agreed upon methodology for determining the factor content of products or industries, empirical studies use a variety of approaches to proxy factor content. One approach is to rank industries according to average wages. If workers are paid their marginal products (as would prevail in competitive markets for factors and goods), then, on average, higher paying industries ought to reflect higher average productivity or skill. Another way to proxy for skill intensity is to rank industries by average education levels. A third approach is to calculate the share of production workers (relative to non-production workers) in each industry.

Because U.S. historical census data provides broad industry coverage and detailed information on education and wages, our starting point for classifying skill intensity for Chinese industries was to create benchmarks based on the 1940 U.S. Census.[12] In particular, the 1940 U.S. Census is the first census that provided information on an individual's education and earnings. The 1940 Census records each individual's highest level of educational attainment, ranging from no education to five or more years of post-secondary education. In our analysis, we classify workers with nine or more years of education as skilled workers. We count the numbers of skilled and unskilled employees in the 1940 Census for each industry (using the IND1950 classification described above) and then calculate the fraction of workers in each industry that had nine or more years of education.

The 1940 Census also records each individual's annual wage, allowing us to aggregate these data and obtain average industry wages (again based on IND1950 industry classification). Hence, using U.S. Census data, we are able to obtain information on skill intensity at the industry level based on (1) education and (2) wages. We report industry rankings using these two metrics in Tables 2 and 3. The Spearman rank correlation coefficient for the two metrics is 0.75, and is significantly different from 0 at conventional levels of significance.

[12] Benchmarking on the U.S. historical census relies on several strong assumptions, such as the existence of the same technologies in the U.S. and China, the same skill intensities of these technologies in the two countries, and the same productivity of factors used in production. As Helpman (1999), Maskus and Nishioka (2008), Davis and Mishra (2007) and others point out, these assumptions might not hold in the real world. However, Chinese industries in that period mostly adopted new technologies from leading industrial countries such as the U.S. Therefore, technologies and their factor contents were similar in these two countries. As a robustness check, later in the paper,

V. Analyzing the Effects of the Chinese Trade Boom on Wages

A. Factor Content Analysis

A first test in the spirit of factor endowments models is to examine whether total exports were becoming more unskilled-intensive in their composition over the course of our sample period. Using the data on industry averages for wages and education, we classify the industrial sectors into two broad groups, unskilled and skilled. We denote industries where the fraction of workers with nine or more years of education exceeded 0.48 as skilled industries. We divide the data at this value since the two industries above and below this cutoff seemed most dissimilar in terms of labor force characteristics (motor vehicles and motor vehicle equipment versus glass and glass products). In a similar way, we also divided the industry data into skilled and unskilled using log wages. Industries with log wage values greater than 2.986 are classified as skilled, which puts metal mining and pottery producing as the two industries on the dividing line.[13] Figures 4 and 5 display the composition of exports and imports in terms of factor content. In 1903, when the magnitude of foreign trade was fairly small and China was relatively closed, most of its imports and exports were composed of unskilled-intensive products. However, as Chinese trade grew in importance over the next 25 years, we see significant movements in the ratios for both exports and imports. Using either wages or education as our measure of skill, exports became more unskilled-intensive over the entire sample period – rising from about 0.92 to 0.99 for the education ratio and from roughly 0.8 to roughly 0.9 for the wage ratio (Figure 4). In contrast, the share of unskilled imports declines substantially. Using the measure based on education, the share of unskilled exports falls form 0.88 to 0.75 (Figure 4, Panel A). In the same vein, the fraction of imports that are skill-intensive increases

we consider an alternative measure of skill intensity at the industry level, based on a more limited Chinese survey of manufacturing.

[13] The results reported later in the paper do not appear that sensitive to changing these cutoffs.

from 0.11 to 0.25 over the sample period (Figure 5). The trend towards more unskilled intensive exports and more skill-intensive imports is particularly pronounced after 1913.

Another way of assessing the general factor content of trade is to examine the detailed industry data. In Figures 6-9, we display the value of exports and imports for each industry on the y-axis and its corresponding skill intensity on the x-axis for four years: 1903, 1913, 1919, and 1928. Skill intensity increases as we move in a rightward direction along the x-axis. We present this evidence for skill intensity based on education (Panel A of Figures 6-9) and log wages (Panel B of Figures 6-9). The figures show that exports are largely clustered at the lower levels of skill intensity whereas imports dominate the highest values of skill intensity. These characteristics of the figures are even more evident by 1928.

These results constitute strong evidence that trade was fundamentally responding in ways that are consistent with factor endowments models of trade. Even if we found no evidence that the unskilled-intensive exports were rising over our sample period, the factor content data could still be consistent with the predictions of factor endowments models if it were true that, overall, Chinese exports grew faster for unskilled-intensive industries than for skill-intensive industries. This would indicate that the expansion in exports shown in Figure 1 was driven by unskilled-intensive exports. (Similarly, skill-intensive imports should grow faster than those for unskilled industries.)

To test this alternative prediction, we divide the data into ten industry groups based on skill intensity and then compute the growth rates for each decile. Tracking the growth in exports of individual industries might be preferable, but it is complicated by the fact that some industries lack data for our whole sample period. Using industry groupings allows us to examine industries of similar skill intensity and follow them over the entire sample period. We weight the deciles by their share of the total value of exports, and then plot the growth rate of exports for each group relative to its skill intensity.

Figures 10-11 graph the average annual growth rates for exports and imports from 1903 to 1928 where industry groups are ordered by skill intensity (using either the wage or education classifications as indicated on the graph). The figures show that the fastest growing deciles for exports tended to be those with the lowest skill intensity. Indeed, since such a large preponderance of exports use unskilled labor intensively, the visual impact of the graph is diminished since there is no way to include all the zero values of industries (not exported) that would be more skill intensive. On the other hand, the fastest growing deciles for imports tended to be the most skill intensive.

B. Robustness Check

In our empirical analysis, we have implicitly drawn on an assumption of the HOV model – that technology is the same across countries – so that we could derive skill intensities for Chinese industries using 1940 U.S. census benchmarks. However, because the assumption of common technology may not have held in practice and because our U.S. skill-intensity benchmarks are based on data from 1940, we explore whether the factor content analysis is robust to an alternative classification scheme. To carry out our robustness check, it is necessary to identify an alternative survey for deriving skill intensity at the industry level. Unfortunately, survey data at the individual, occupational, or industry level for China during the first three decades of the twentieth century are very scarce.

The 1928 Shanghai Census is the earliest survey that contains information sufficient to derive estimates of skill intensity at the industry level. It was administered by the Bureau of Industry, Agriculture, and Commerce of the Greater Shanghai Municipality and included information on factory names and addresses, ownership, capitalization, number of workers, wages, raw materials, and power utilization. The survey records only the highest and lowest wage rates by industry rather than average industry wages. Rather than using the minimum and maximum wage data (which would likely produce unreliable estimates for computing factor intensity), we instead used information on inputs to compute the capital-labor ratio to evaluate skill intensity of industries. For these calculations, we assume that industries which use more labor are, on average, characterized by lower-skilled workers. We first classified the traded goods using the classification system adopted in the 1928 Shanghai Survey, and then calculated the capital-labor ratio by dividing the total physical capital (value of physical capital stock) by the number of workers in each industry. We then ranked the traded goods industries according to their capital-labor ratios (Table 4).

Figures 12 and 13 show that, using the 1928 Shanghai survey produces results that are similar to those based on the U.S. skill-intensity benchmarks. Growth rates for Chinese exports were highest for unskilled industry deciles and growth rates for imports were highest for the skilled deciles.

C. Evidence on the Price of Exports

Factor endowment theories suggest that changes in product prices are the mechanism that alters trade flows and factor prices. Therefore, a necessary condition for trade to impact the skill premium is a change in the price of exports. We have thus far shown that China became more specialized in producing and exporting unskilled intensive commodities. Assuming the marginal product of workers has not changed, if export prices rise substantially, the skill premium in China will eventually fall, since Chinese exports use relatively more unskilled labor in their production. [14]

Hsiao's (1974) export price index shows that export prices grew markedly after 1913 (Figure 14).[15] Consistent with other global studies of trade, prices of traded goods rose during World War I. Moreover, it appears that in China's case, the positive shock in demand was large enough to significantly move prices upward after a decade of little change. After a brief cessation after the war, prices resumed their upward trajectory. During the period when the skill premium was flattening out and falling, export prices roughly doubled. Rising sales and prices led to growing revenue for exporting firms, providing

[14] Ideally, we would prefer to use the terms of trade rather than just the price of exports. In arguing that wages will respond to changes in the terms of trade, a conventional factor endowments model assumes identical trade costs for exports and imports. However, for our Chinese data, this is not the case. The price of exports is F.O.B. and price of imports is C.I.F. The key difference between these two measures is that C.I.F. measure for imports includes transportation (freight) and insurance costs (Cheng, 1956; Hsiao, 1974). During World War I, freight costs and insurance rates rose dramatically. For example, Mohammed and Williamson (2004, p.180) show that a nominal freight rates index for a representative Asian trade route increased from 0.702 in 1914 to 14.874 by 1918 – an increase of more than 2000 percent. Using a global index, real freight rates roughly tripled during World War I, according to Mohammed and Williamson (2004, p.88). Hence, using C.I.F. import prices dramatically overstates the true price of imports, relative to our F.O.B. exports series. Using import prices would thus produce a biased terms of trade series that is much different from what theory suggests is appropriate for measuring the impact of trade on wages.

[15] The export prices shown in Figure 14 are the prices in silver. The export prices relative to the price of gold show similar qualitative results: the price increased by 28 percent from 1903 to 1913, but by 120 percent from 1914 to 1919, and by 60 percent from 1914 to 1928.

considerable scope for raising the wages of unskilled workers that were used intensively in their production.

We used the unit value data contained in our database to compute the growth rates in prices for China's ten most important exports (based on value). Figure 15 shows positive average annual growth rates in unit values for these major exports over the period 1903 to 1928. For nine of the ten chief exports, the growth rates were faster after 1914 (Panel B). In addition, the commodities shown in this figure that used unskilled labor more intensively (agricultural goods and cotton yarn) experienced particularly strong rates of growth in their prices. Figure 16 shows that prices in cotton yarn grew by 275 percent after 1913. Cotton spinning was widely considered a typical unskilled-intensive manufacturing industry. China had been a large importer of cotton yarn, but by the beginning in the twentieth century, a domestic cotton textile industry began to compete with foreign products. The industry grew rapidly, and by the mid-1920s, cotton-spinning exports exceeded imports.

As the cotton spinning industry expanded, it drew in large numbers of unskilled workers. Real wages in cotton textiles increased by more than 50% during the war, remained at those levels after the war ended, and then continued an upward trajectory into the 1920s (Liu 1936). Although additional industry-level wage data are quite scarce, we were able to obtain figures for real wages for two other key exports. Real wages in the silk industry grew by more than 150% during the war and then, after flattening out at the conclusion of the war, continued their upward trajectory. Similarly, real wages for coal workers (based on Kailun, one of the largest mines in China at that time) grew by more than 25% during the 1920s.[16] These data suggest that wages were rising in the export sector in response to higher product prices.

Although it is impossible to rule out alternative explanations, the movements in the skill premium data seem most consistent with a trade shock rather than either a dramatic rise in the quantity of skilled workers in the 1920s or very rapid technological change. The limited data that are available on Chinese education rates suggest that the expansion of skilled workers due to increased opportunities was small and likely came too late in our sample period to account for the observed decline in the skill premium. As noted earlier, some technological advances in China appear to have been ongoing in industries like cotton textiles, and they tended to raise the demand for unskilled workers rather than displace them. It is therefore possible that some of the boost in trade we observe during our sample period is associated with technological change in manufacturing, which perhaps resulted from the foreign direct investment into China from Japan and other countries at the beginning of the 20th century. Nevertheless, in cotton textiles and other mechanized manufacturing industries in China, the pace of technological change was incremental. There were no sudden surges that occurred in the 1910s and 1920s that would be consistent with the rather abrupt reversal in the wage premium over these decades. If anything, the pace of technological change was slower during the war period due to the difficulty of importing new machinery from western countries engaged in combat. The reversal in the upward trend and flattening out of the skill premium that occurred during this decade would therefore be inconsistent with technology being the main driver. Moreover, in the vast majority of other sectors of the economy, particularly agriculture, handicraft industries, and mining, there was little technological progress during the first three decades of the twentieth century.

VI. Model and Simulation

A. Benchmark model

To better understand trade's contribution to the change in the skill premium in the 1910s and 1920s, we now model a price shock to Chinese exports in a general-equilibrium, factor-endowments framework. We then simulate this model using data on the Chinese economy to examine whether our empirical findings are plausible and consistent with theory. We first consider a closed economy model as

[16] We were unable to locate data for real wages in the coal industry prior to 1919 or for other key export industries so that we could carry out a more detailed statistical analysis in a panel setting. Recall, the wage data from Yan (2008) are occupational and not at the industry level.

a benchmark. In the subsequent subsection, we extend the dynamic model to an open economy subject to price shocks.

Suppose there are two intermediate goods and one final good.[17] Prices of intermediate goods are denoted as p_t^1 and p_t^2 and p_t^f is the price of the final good. We set the second intermediate good as a numeraire and hence normalize p_t^2 to be 1. Output for the final good, Y_t^f, is produced using a standard CES specification where

$$Y_t^f = [\gamma (Y_t^1)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\gamma)(Y_t^2)^{\frac{\varepsilon-1}{\varepsilon}}]^{\frac{\varepsilon}{\varepsilon-1}} \tag{1}$$

where Y_t^1 and Y_t^2 are intermediate goods, γ and 1-γ are the relative shares of two intermediate goods, and ε is the elasticity of substitution between two intermediate goods. By profit maximization,

$$\frac{Y_t^1}{Y_t^2} = (\frac{\gamma}{1-\gamma}\frac{1}{p_t^1})^{\varepsilon}. \tag{2}$$

Thus we have

$$p_t^f = (\gamma^{\varepsilon}(p_t^1)^{1-\varepsilon} + (1-\gamma)^{\varepsilon})^{\frac{1}{1-\varepsilon}}. \tag{3}$$

The production for intermediate good 1 uses unskilled labor, L_t^1, and land, T, with the shares δ and $1-\delta$ respectively. Land has a fixed supply, so we normalize the supply of land to be 1. Hence, we specify the production function of intermediate good 1 as the following:

$$Y_t^1 = A^1 (L_t^1)^{\delta}, \tag{4}$$

where $0 < \delta < 1$. For simplicity, we assume the technology used to produce intermediate good 1, A^1, is constant. Assuming labor markets are perfectly competitive, the wage for unskilled labor will be equal to its average product:

$$w_t^1 = p_t^1 A^1 (L_t^1)^{\delta-1}. \tag{5}$$

[17] We specify production this way since many developing countries import intermediate goods and export final goods.

On the other hand, the production of intermediate good 2 uses both skilled and unskilled labor and is specified as a constant returns to scale production function:

$$Y_t^2 = A_t^2 (H_t^2)^{\alpha} (L_t^2)^{1-\alpha}, \tag{6}$$

where H_t^2 and L_t^2 are skilled and unskilled labor, respectively. The shares of these two inputs are α and $1-\alpha$, respectively. Again, assuming perfectly competitive labor markets, the wage for skilled labor, w_t^H, and that of unskilled labor, $w_t^{L,2}$ are their marginal products:

$$w_t^H = \alpha A_t^2 (H_t)^{\alpha-1} (L_t^2)^{1-\alpha}, \tag{7}$$

$$w_t^{L,2} = (1-\alpha) A_t^2 (H_t)^{\alpha} (L_t^2)^{-\alpha}. \tag{8}$$

Since unskilled labor can move freely among all the sectors, wages for unskilled labor will equalize across all the sectors of the economy so that

$$w_t^L = w_t^1 = w_t^{L,2}. \tag{9}$$

Hence, we define the skill premium as

$$s_t = \frac{w_t^H}{w_t^L} = \frac{\alpha}{1-\alpha} \frac{L_t^2}{H}. \tag{10}$$

We assume that the technology used for the production of intermediate good 1 grows slower than that in intermediate good 2. We make this assumption to characterize the fact that the productivity of the industrial sector improves rapidly through modernization (perhaps even through the importation of foreign technologies). Without losing generality, we simplify the model by assuming that A_1 is constant over time, while A_2 grows at a positive rate of g, i.e.

$$A_{t+1}^2 = (1+g) A_t^2. \tag{11}$$

In our model, there are two types of consumers that optimize over their lifetimes. Consumer *i*, $i \in \{L, H\}$, maximizes lifetime utility as specified by a CRRA utility function:

$$\sum_{t=0}^{\infty} \beta^t \frac{(c_t^i)^{1-\sigma} - 1}{1-\sigma}. \tag{12}$$

Consumers can borrow and lend at interest rate, r, in any period, which is exogenous to our model. Therefore, the budget constraint of consumer i, $i \in \{L, H\}$, is:

$$\sum_{t=0}^{\infty} \frac{p_t c_t^{\,i}}{(1+r)^t} \le \sum_{t=0}^{\infty} \frac{w_t^{\,i}}{(1+r)^t}. \tag{13}$$

To optimize utility, the consumer thus maximizes equation (12) subject to (13).

We also assume the total supply of skilled workers is fixed at H and the total supply of unskilled labor is fixed at L so that the market-clearing conditions for the labor market are:

$$H = H_t, \tag{14}$$

$$L = L_t^{\,1} + L_t^{\,2}. \tag{15}$$

We define a competitive equilibrium as follows:

Definition of Competitive Equilibrium: A competitive equilibrium consists of consumption $\{c_t^{\,L}, c_t^{\,H}\}$, production of each good $\{Y_t^f, Y_t^1, Y_t^2\}$, labor supply $\{H, L\}$, labor demand $\{L_t^{\,1}, L_t^{\,2}, H_t\}$, wages $\{w_t^{\,L}, w_t^{\,H}\}$, prices of final good and two intermediate goods $\{p_t^{\,f}, p_t^{\,1}, p_t^{\,2}\}$, and a law of motion g for the state variable, technology, such that:

(1) consumption is the solution to the utility maximization problem;

(2) labor demand and wages satisfy equations (5), (7), (8) and (9);

(3) labor supply is fixed;

(4) labor supply and labor demand satisfy equations (14) and (15);

(5) the law of motion g satisfies equation (11);

(6) the price of intermediate good satisfies equations (2) and (9);

(7) the price of final good satisfies equation (3); and

(8) the production of each good satisfies equations (1), (4), and (6).

B. An Open Economy Model with Price Shocks

We now extend the model to describe an open economy with exogenous trade shocks. Trade shocks are modeled as exogenous increases in the prices of the final good. Price shocks induce the home country to import more intermediate goods from abroad to produce and export more of the final good. To relate the open economy version of the model to our empirical analysis of China, we assume the home country is abundant in unskilled labor and scarce in skilled labor. Following factor endowment theories, we assume the home country therefore has a comparative advantage in producing intermediate good 1 and a comparative disadvantage in producing intermediate good 2. It will therefore import intermediate good 2 in order to raise the production capacity.

Based on this framework, the market for the final good can be described by:

$$Y_t^f + EX_t = (\gamma(Y_t^1)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\gamma)(Y_t^2 + IM_t)^{\frac{\varepsilon-1}{\varepsilon}})^{\frac{\varepsilon}{\varepsilon-1}}, \tag{16}$$

where Y_t^f is domestic consumption of the final good, EX_t is the amount of final good exported, Y_t^2 is domestic production of intermediate good 2, and IM_t is the quantity of intermediate good 2 imported.

We assume that the home country is a small economy and is thus a price taker in the market for both the final good and intermediate good 2. Therefore, p_t^f and p_t^2 are exogenous and determined by global supply and demand. Since we have not modeled the capital account, we assume balance of trade for each period so that:

$$p_t^f EX_t = p_t^2 IM_t. \tag{17}$$

C. Analysis and Simulation of the Skill Premium

We now examine how the skill premium evolves in the two versions of the model. In the benchmark closed-economy model, since the total factor productivity (TFP) of intermediate good 2 grows over time while the TFP of intermediate good 1 is constant, unskilled labor will migrate out of the production of intermediate good 1 and into the production of intermediate good 2 until the asymptotic steady state is reached. As described by equation (10), the skill premium will therefore rise until it becomes flat after reaching the asymptotic steady state. If we conceptualize intermediate good 1 as describing production in the agricultural sector, and intermediate good 2 as describing the industrial sector, the benchmark model describes the rising skill premium that is typically associated with industrialization and faster TFP growth in the industrial sector.

In the open economy model, the skill premium evolves differently. A persistent increase in the price of the final good induces the home country to produce and export more of the final good, using intermediate goods produced domestically (by both skilled and unskilled labor) as well as some that are imported from abroad. Since the home country has a comparative advantage in producing intermediate good 1, it will import intermediate good 2. In contrast to the benchmark model, the open economy model will slow down the migration of unskilled labor from intermediate good 1 to intermediate good 2 since unskilled labor is needed in order to produce more of the final good for the global market. If the price shocks are sufficiently large and persistent, unskilled labor will move back into the production of intermediate good 1, thus driving down the home country's skill premium. The production of intermediate good 2 in the home country shrinks, and the home country imports intermediate good 2 to produce the final good.

We can show this by solving the close form of the model. Equation (11) shows that the skill premium depends solely on L_t^2, the amount of unskilled labor used in producing intermediate good 2. Hence, we need to solve the relationship between price shocks and unskilled employment in the sector of intermediate good 2.

Assuming profit maximization and the production function for the final good shown in equation (16): we obtain the following optimal condition

$$\frac{Y_t^1}{Y_t^2 + IM_t} = \left(\frac{\gamma}{1-\gamma}\frac{p_t^2}{p_t^1}\right)^{\varepsilon}. \tag{18}$$

Plugging this back to equation (16), we have

$$p_t^f = \left(\gamma^{\varepsilon}(p_t^1)^{1-\varepsilon} + (1-\gamma)^{\varepsilon}(p_t^2)^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}. \tag{19}$$

Given equation (10), the unskilled wages in two sectors are equal. This yields

$$p_t^1 A^1 (L_t^1)^{\delta-1} = p_t^2 (1-\alpha) A_t^2 H^\alpha (L_t^2)^{-\alpha} . \qquad (20)$$

Again, we set the second intermediate good as a numeraire and hence normalize p_t^2 to be 1. Equation (19) shows that the price of intermediate good 1, p_t^1, will increase as the price of the final good, p_t^f, rises. Equation (20) shows that, as long as p_t^1 rises faster than A_t^2, L_t^1 will increase and L_t^2 will decrease so that the equation holds. In other words, the increase in the price of intermediate good 1 tends to attract unskilled workers to move back into the production of intermediate good 1, and by equation (10), this will reduce the skill premium.

We simulate our general equilibrium model using computational methods so that we can consider the effects of the exogenous price shock of World War I on Chinese exports and the skill premium. We use parameters from the existing literature and the actual data on the prices of Chinese trade to conduct a simulation. The values and sources of parameters are shown in Table 5. We also feed the actual price indices of Chinese imports and exports from 1914 to 1928 into our simulation.

Figure 17 shows that the simulation produces a flattening out and decline in the skill premium, the same general shape as observed in the actual data. The decline in the skill premium is somewhat more pronounced in the simulation than in the actual data (roughly 11% versus 8%), but the change in the slope is consistent with what the observed Chinese data. There are several reasons why the model produces a sharper decline in the skill premium than the actual data. First, the model assumes a finite horizon, with the shock ending in 1928, while in the real world, agents maximize utilities over a much longer horizon. Second, the model also assumes balanced trade for each year in the model whereas China's actual trade was unbalanced. Third, physical capital accumulation and other dynamic mechanisms, not included in the model, also affect the skill premium in the real world. Despite the differences in the magnitudes of decline, the model successfully shows that price shocks to exports are capable of driving down the skill premium, a prediction consistent with factor endowment theories of trade.

VII. Conclusion

Our findings suggest that the opening of China to trade during the first three decades of the twentieth century and the shock of World War I led to a dramatic expansion in exports. Prices of exports, especially those for unskilled goods, grew rapidly, particularly after 1913. The price shocks to exports and rising foreign demand for Chinese goods led to greater specialization and increased production of unskilled-intensive products. Unskilled-intensive exports, already dominant in Chinese trade, increased their share of total trade over these decades.

Although we cannot completely rule out alternative explanations, the evidence on factor content of trade and unit values suggests that the rapid expansion in exports from Chinese trade significantly altered the skill premium in China. It appears that once export prices began to rise dramatically during the second decade of the trade boom, wages of unskilled workers relative to skilled workers changed sufficiently to alter the slope of the skill premium. By the 1920s, the skill premium had reversed course and declined by roughly 8 percent.

The large and exogenous upward movement in export prices that coincided in with World War I suggests that the causality likely runs from trade to wages. Our simulation of an open economy model provides further confirmation that a price shock such as World War I can produce the observed movements in exports and the skill premium. What is particularly interesting about the data is that China's exports continue to grow long after the war ends, suggesting that as China increasingly produced and marketed goods for export, it may have benefited from learning and dynamic economies of scale. In this case, then temporary shocks like World War I, can have lasting consequences on trade flows (Krugman, 1987).

Our findings suggest that, in a world when trade was dominated by the movement of relatively homogenous goods across borders, trade may have had a considerable impact on wages. The declining wage inequality in China during the second two decades of the twentieth century stands in contrast to studies examining the recent period of globalization, which emphasize how trade and globalization has widened skill premiums in developing countries (Goldberg and Pavcnik, 2007). The growth in Chinese exports during the first three decades of the twentieth century was centered on products that used unskilled labor intensively. We have suggested that this earlier era of globalization was less influenced by trade in intermediate inputs (i.e., outsourcing), increases in capital flows, and complementarity of capital with skilled labor – factors that have played a role in widening skill premiums today in developing countries.[18] However, as emphasized in the research on the current period of globalization, we acknowledge that our findings pertain only to China and may not generalize to other developing countries even during our sample period, since countries experienced globalization in different ways and at different times.

[18] The observed decline in the skill premium in China also seems inconsistent with Melitz-type models of "firm upgrading" in that these predict a higher demand for skilled workers as trade openness occurs; this suggests that these models may be less well suited for explaining trade-induced movements in the skill premium during the first era of globalization.

Appendix: Data on the Skill Premium

Yan (2008) constructs detailed estimates of real wages and the skill premium for China between 1858 and 1936. Nominal wages are collected from the records of employees in the CMC for nearly fifty Chinese cities, and the wage series are estimated from these records using the Hedonic regression method. The author also constructs group-specific cost of living indices from price data and household budget information contained in CMC trade statistics and surveys. The resulting nominal wage series and cost of living indices make it possible to estimate long-run trends in real wages and skill premia for three basic categories of Chinese workers: unskilled, skilled, and highly skilled. 44,600 wage observations are collected from CMC archives. Roughly half of the archives pertain to labor, which include surveys of local wages and standards of living, CMC wage scales, and most importantly, the Service Lists – that is, the individual personnel records of CMC employees. In each year the Service Lists recorded each employee's name, home town, year of joining the service, year of being promoted, year transfer to the current customhouse, rank, and monthly salary.

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Table 1. Leading Chinese Exports, by Product, 1903-1928

Units: thousand piculs (for coal: thousand tons)

Year	Raw Cotton	Tea	Ground nut	Bristle	Cotton yarn
1903	760	1678	157	40	
1914	675	1496	592	51	4
1919	1072	690	137	52	67
1928	1112	926	933	67	350

Year	Coal	Bean cake	Wheat Flour	Raw silk	Vegetable Oil
1903	76	3404		211	421
1914	2006	10769	70	226	1304
1919	1477	20725	2694	346	4199
1928	3885	21352	86	435	2368

Source: Hsiao (1974)

Table 2. Ranking of Industries by Educational Attainment

IND1950	Industry	Fraction of Skilled Employees
377	Aircraft and parts	0.72
459	Printing, publishing, and allied industries	0.68
357	Office and store machines	0.64
386	Professional equipment	0.62
367	Electrical machinery, equipment and supplies	0.62
476	Petroleum refining	0.59
468	Paints, varnishes, and related products	0.58
458	Misc paper and pulp products	0.57
407	Dairy products	0.57
346	Fabricated steel products	0.55
478	Rubber products	0.54
226	Crude petroleum and natural gas extraction	0.54
466	Synthetic fibers	0.54
358	Misc machinery	0.54
469	Misc chemicals and allied products	0.53
356	Agricultural machinery and tractors	0.53
418	Beverage industries	0.52
388	Watches, clocks, and clockwork-operated devices	0.52
409	Grain-mill products	0.51
416	Bakery products	0.51
449	Misc fabricated textile products	0.49
376	Motor vehicles and motor vehicle equipment	0.49
316	Glass and glass products	0.48
338	Primary nonferrous industries	0.48
436	Knitting mills	0.48
457	Paperboard containers and boxes	0.47
426	Not specified food industries	0.47
456	Pulp, paper, and paper-board mills	0.47
417	Confectionary and related products	0.47
406	Meat products	0.46

Note: Traded goods were classified into industries using the IND1950 described in the text. Educational attainment is derived using 1940 US census. Please see the text for details.

Table 2. Ranking of Industries by Educational Attainment (continued)

IND1950	Industry	Fraction of Skilled Employees
489	Leather products, except footwear	0.46
378	Ship and boat building and repairing	0.45
487	Leather: tanned, curried, and finished	0.45
337	Other primary iron and steel industries	0.44
477	Misc petroleum and coal products	0.44
379	Railroad and misc transportation equipment	0.44
488	Footwear, except rubber	0.43
326	Misc nonmetallic mineral and stone products	0.43
408	Canning and preserving fruits, vegetables, and seafood	0.43
319	Pottery and related prods	0.43
446	Misc textile mill products	0.42
437	Dyeing and finishing textiles, except knit goods	0.42
308	Misc wood products	0.42
309	Furniture and fixtures	0.42
348	Not specified metal industries	0.41
206	Metal mining	0.41
336	Blast furnaces, steel works, and rolling mills	0.4
317	Cement, concrete, gypsum and plaster products	0.4
448	Apparel and accessories	0.39
116	Forestry	0.37
438	Carpets, rugs, and other floor coverings	0.35
318	Structural clay products	0.33
439	Yarn, thread, and fabric	0.32
246	Construction	0.31
429	Tobacco manufactures	0.3
307	Sawmills, planting mills, and mill work	0.28
236	Nonmetallic mining and quarrying, except fuel	0.27
126	Fisheries	0.26
105	Agriculture	0.22
306	Logging	0.22
216	Coal mining	0.2

Table 3. Ranking of Industries by Log Wages

IND1950	Industry	Log Wage
476	Petroleum refining	3.207
226	Crude petroleum and natural gas extraction	3.127
468	Paints, varnishes, and related products	3.126
378	Ship and boat building and repairing	3.124
459	Printing, publishing, and allied industries	3.124
357	Office and store machines	3.122
358	Misc machinery	3.109
418	Beverage industries	3.1
469	Misc chemicals and allied products	3.099
376	Motor vehicles and motor vehicle equipment	3.098
367	Electrical machinery, equipment and supplies	3.095
386	Professional equipment	3.092
478	Rubber products	3.092
336	Blast furnaces, steel works, and rolling mills	3.091
356	Agricultural machinery and tractors	3.078
346	Fabricated steel products	3.075
406	Meat products	3.07
377	Aircraft and parts	3.067
407	Dairy products	3.06
337	Other primary iron and steel industries	3.055
338	Primary nonferrous industries	3.055
456	Pulp, paper, and paper-board mills	3.048
316	Glass and glass products	3.047
348	Not specified metal industries	3.045
317	Cement, concrete, gypsum and plaster products	3.036
416	Bakery products	3.032
426	Not specified food industries	3.031
379	Railroad and misc transportation equipment	3.03
487	Leather: tanned, curried, and finished	3.028
326	Misc nonmetallic mineral and stone products	3.024
466	Synthetic fibers	3.023
388	Watches, clocks, and clockwork-operated devices	3.02

Note: Traded goods were classified into industries using the IND1950 described in the text. Log wage is derived using 1940 US census. Please see the text for details.

Table 3. Ranking of Industries by Log Wages (continued)

IND1950	Industry	Log Wage
477	Misc petroleum and coal products	3.017
409	Grain-mill products	3.011
458	Misc paper and pulp products	3.007
206	Metal mining	3.006
319	Pottery and related products	2.986
446	Misc textile mill products	2.984
438	Carpets, rugs, and other floor coverings	2.973
318	Structural clay products	2.954
457	Paperboard containers and boxes	2.953
309	Furniture and fixtures	2.943
437	Dyeing and finishing textiles, except knit goods	2.937
308	Misc wood products	2.931
489	Leather products, except footwear	2.913
417	Confectionary and related products	2.905
216	Coal mining	2.9
436	Knitting mills	2.897
488	Footwear, except rubber	2.886
429	Tobacco manufactures	2.865
236	Nonmetallic mining and quarrying, except fuel	2.85
439	Yarn, thread, and fabric	2.847
408	Canning and preserving fruits, vegetables, and seafood	2.827
307	Sawmills, planting mills, and mill work	2.815
448	Apparel and accessories	2.812
246	Construction	2.796
449	Misc fabricated textile products	2.79
306	Logging	2.703
116	Forestry	2.682
126	Fisheries	2.666
105	Agriculture	2.095

Table 4. Ranking of Industries by the 1928 Shanghai Survey

Industry Code	Industry Name	Capital-Labor Ratio Unit: Chinese Yuan per worker
93	Electric and water works	10628.86
46	Condiments	5169.01
26	Medicine	4356.16
47	Cigars and cigarettes	4298.39
71	Metal products	3746.26
27	Manufacture of paper	3118.92
31	Manufacture of varnish	2099.24
29	Manufacture of enameled ware	2009.51
73	Musical instruments and toys	1810.9
28	Match making	1668.87
91	Building material	1582.64
25	Glassware	1342.49
63	Founding	1163.01
86	Clothing	1142.16
92	Coal briquettes	1140.46
23	Cosmetics	977.14
74	Scientific apparatus	955.95
41	Wheat flour mills	900.91
43	Oil mills	881.55
45	Frozen egg products	782.83
32	Other chemical	739.37
51	Printing	727.67
81	Hats	722.83
75	Other tools and instruments	641.51
21	Dyeing and printing of textiles	618.92
48	Candies and canned food	598
49	Other food	501.96

Note: Traded goods were classified into industries using the 1928 Shanghai survey data described in the text. Capital-labor ratio is derived using this survey too. Please see the text for details.

Table 4. Ranking of Industries by the 1928 Shanghai Survey (continued)

Industry Code	Industry Name	Capital-Labor Ratio
16	Knitted goods	488.5
17	Other textile	477.26
62	Manufacture of electrical instruments	396.32
94	Trimmings and ribbons	387.11
82	Umbrellas	379.27
11	Cotton spinning	357.99
97	Other miscellaneous industries	344.68
83	Brushes	325.1
84	Writing outfit	294.87
12	Cotton weaving	277.37
15	Wool weaving	258.09
22	Leather manufacturing	241.06
64	Shipbuilding	240.55
14	Silk weaving	204.25
96	Cotton ginning	203.19
85	Spectacles	188.54
72	Wooden, rattan, and bamboo articles	146.68
44	Soda water and other soft drinks	129.78
24	Soap and candles	127.62
87	Other daily necessities	114.09
61	Manufacture and repairing of machines	81.27
42	Rice mills	59.77
13	Silk reeling	47.69
95	Cartons	38.1

Table 5. Parameters for Simulation

Parameter	Values
γ	0.5
ε	3
α	0.78
δ	0.6
A^1	0.22
A^2	1.04
g	0.01
H	1
L	200

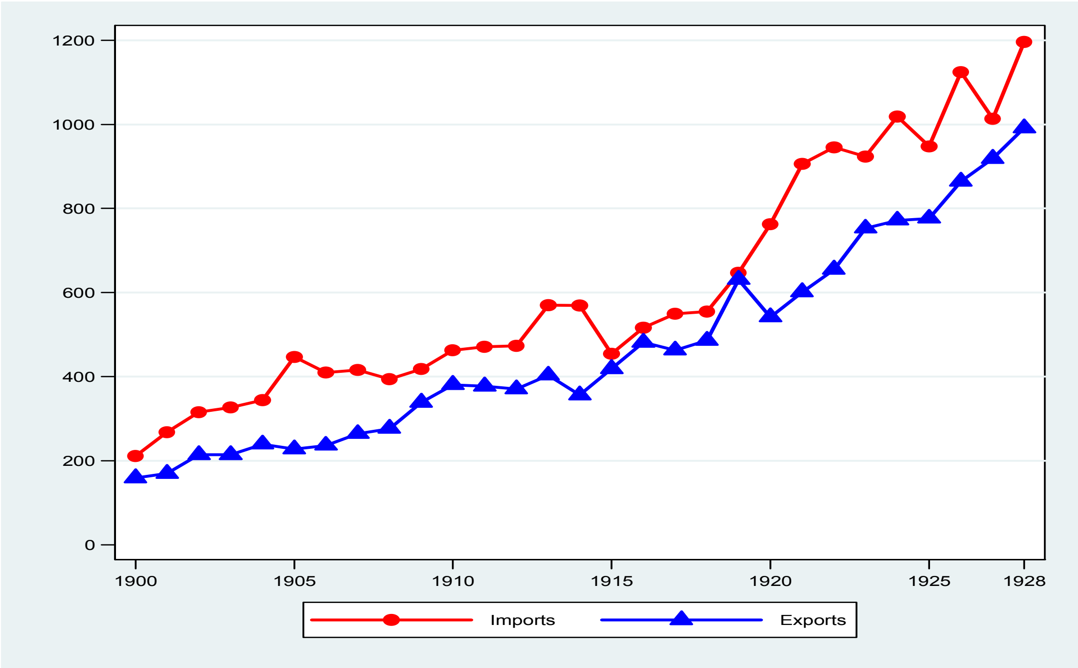
Sources of Parameters:

1. We set the value of γ arbitrarily to equal 0.5, which means the two intermediate goods are equally important in production. Results do not appear sensitive to other values.
2. ε : Burstein and Vogel (2009).
3. α , and δ : Doepke (2004) .
4. A^1 and A^2 : Acemoglu and Zilibiotti (2001).
5. g, H and L : are set according to historical estimates of the labor force in China.

Figure 1. The Value of China's Foreign Trade

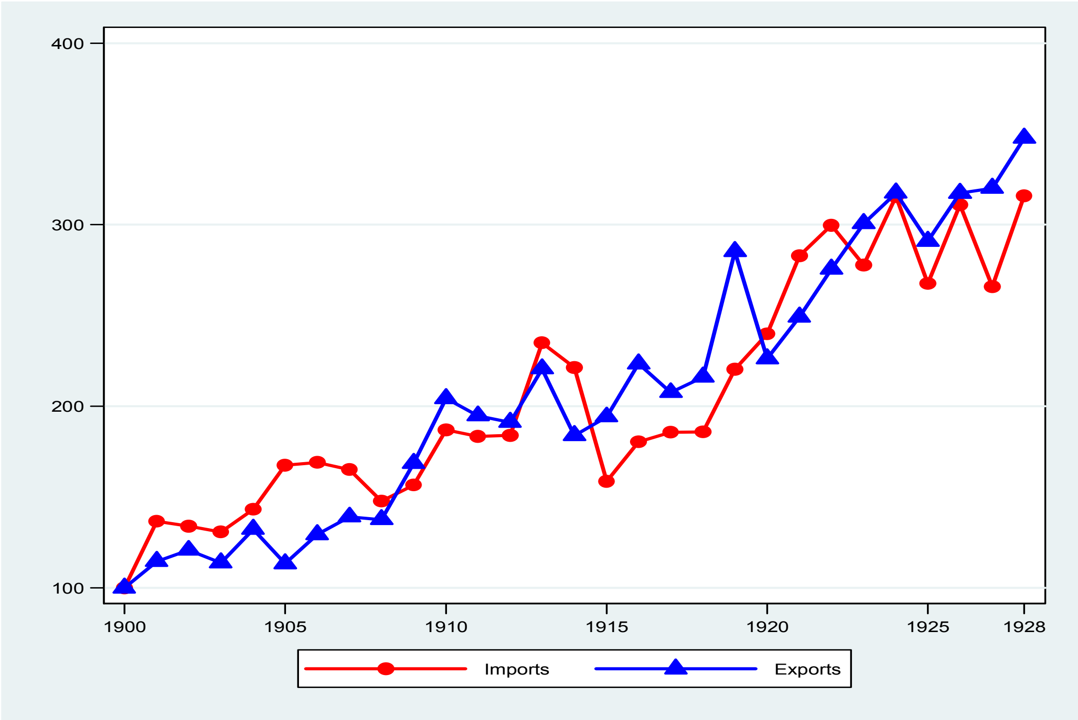
Panel A: Nominal value of trade

Unit: thousand Haikwan Tael



Source: Hsiao (1974)

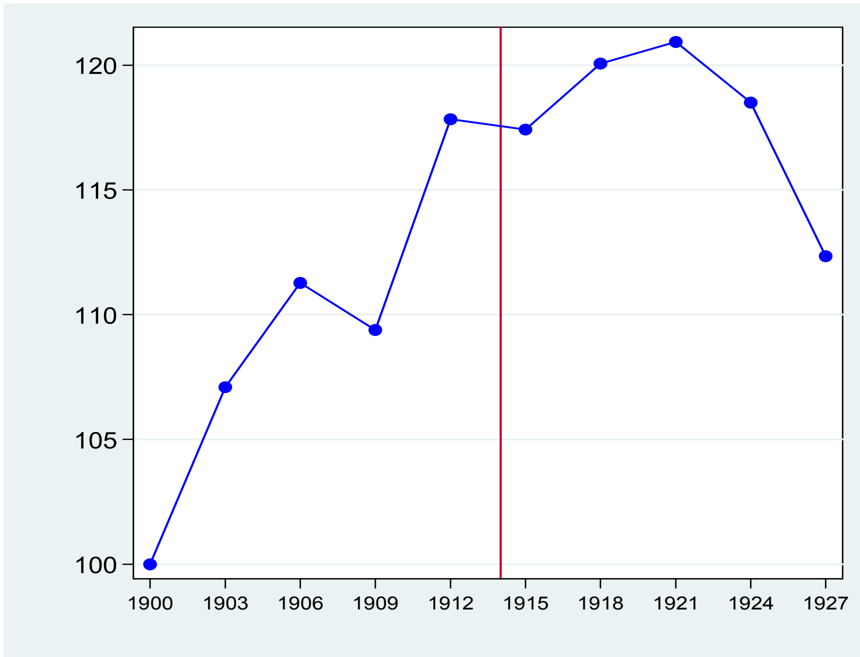
Panel B: Real value of trade
Index: 1900=100



Source: Authors' calculations based on data from Hsiao (1974)

Figure 2. Real Wage Premium in China

Index: 1900=100



Source: Yan (2008)

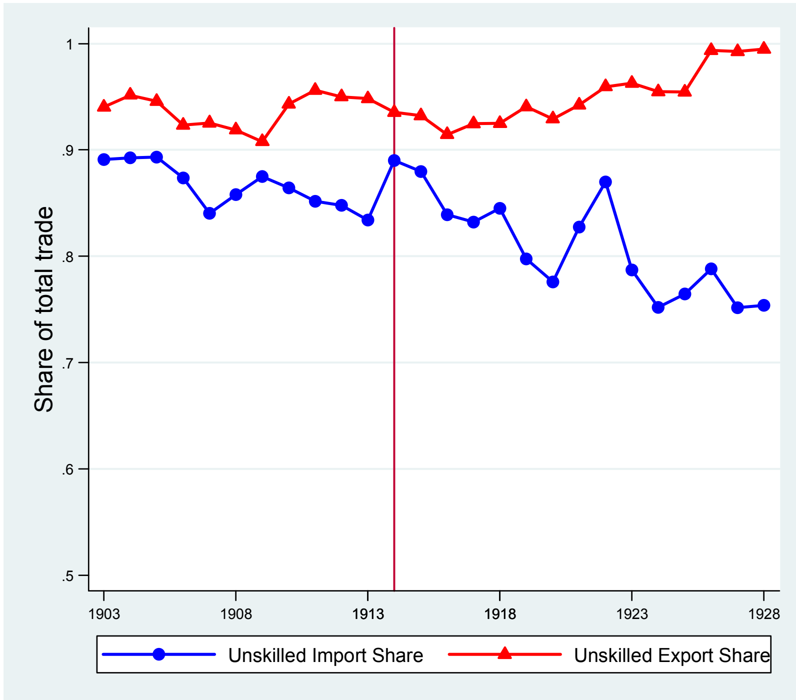
Figure 3. Quantities of Foreign Imports and Exports of Cotton Yarn, 1910-1935

Unit: thousand piculs

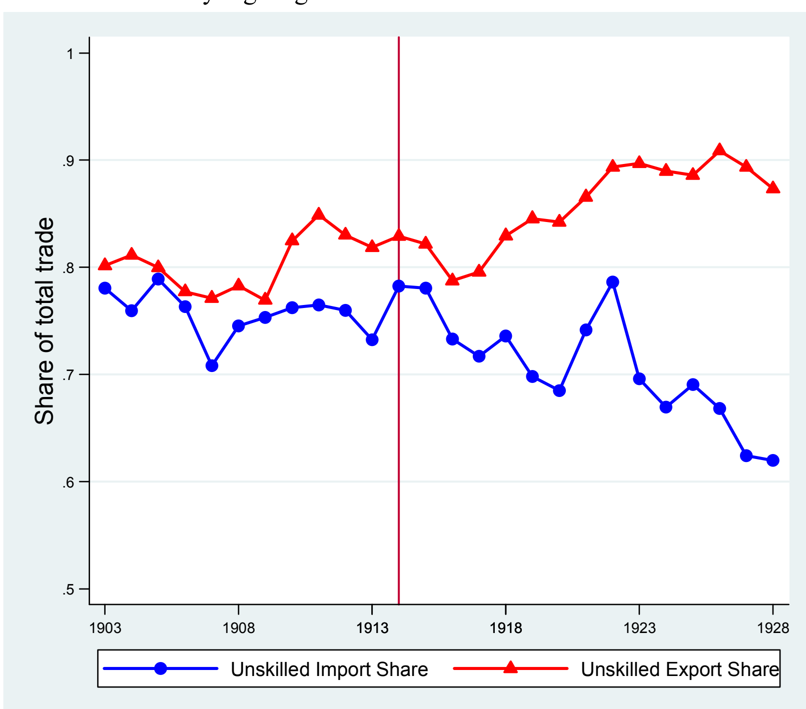
Source: Hsiao (1974)

Figure 4. Unskilled Export and Import Shares, 1903-1928

Panel A: Unskilled trade as classified by educational attainment



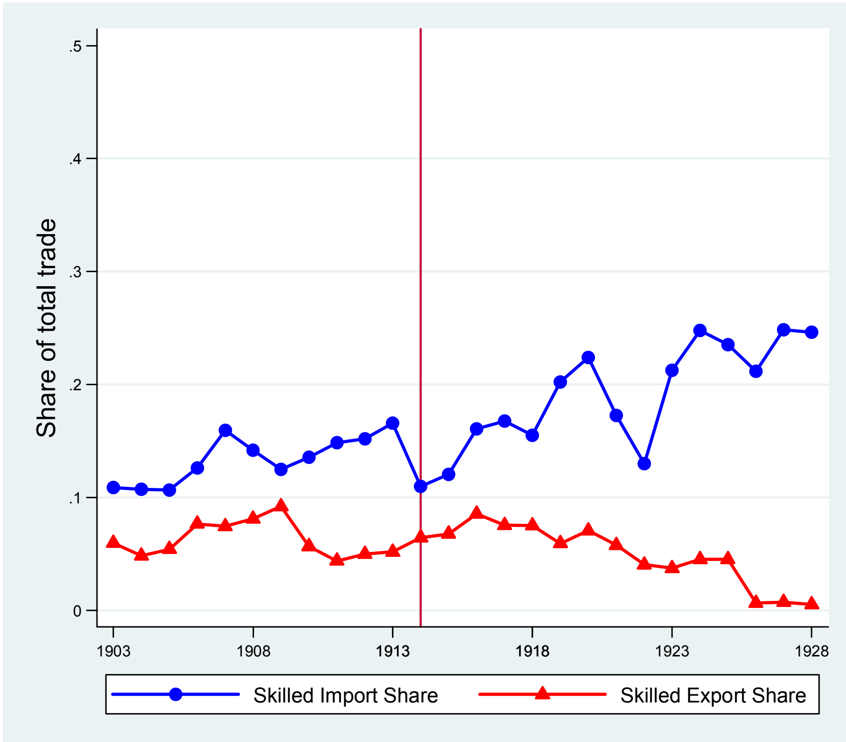
Panel B: Unskilled trade as classified by log wage



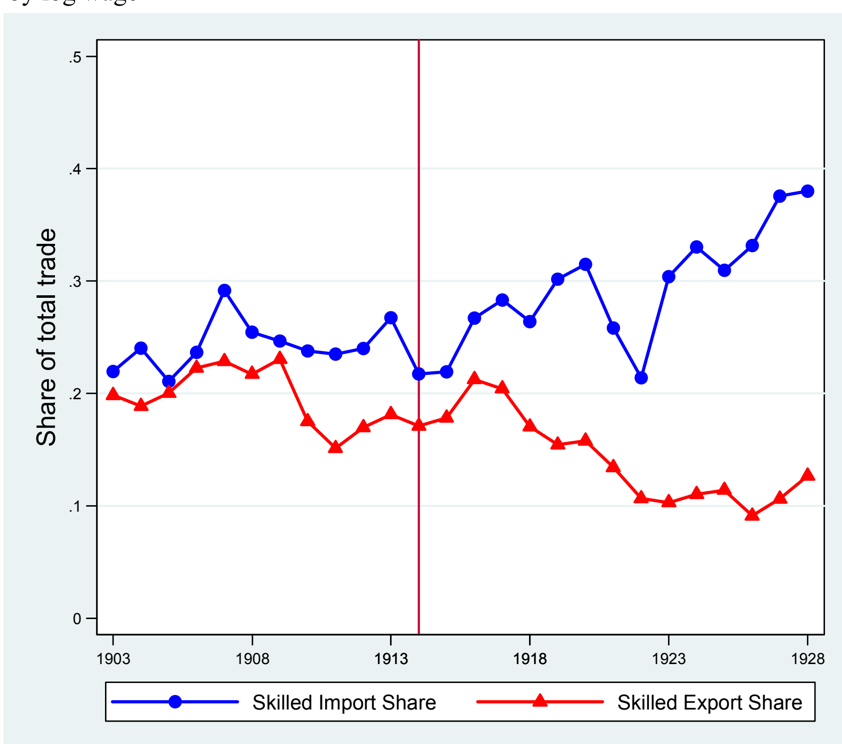
Notes: Authors' calculations based on data from the 1940 US census. See the text for a description of the educational attainment and average wages.

Figure 5. Skilled Export and Import Shares, 1903-1928

Panel A: classified by educational attainment



Panel B: classified by log wage

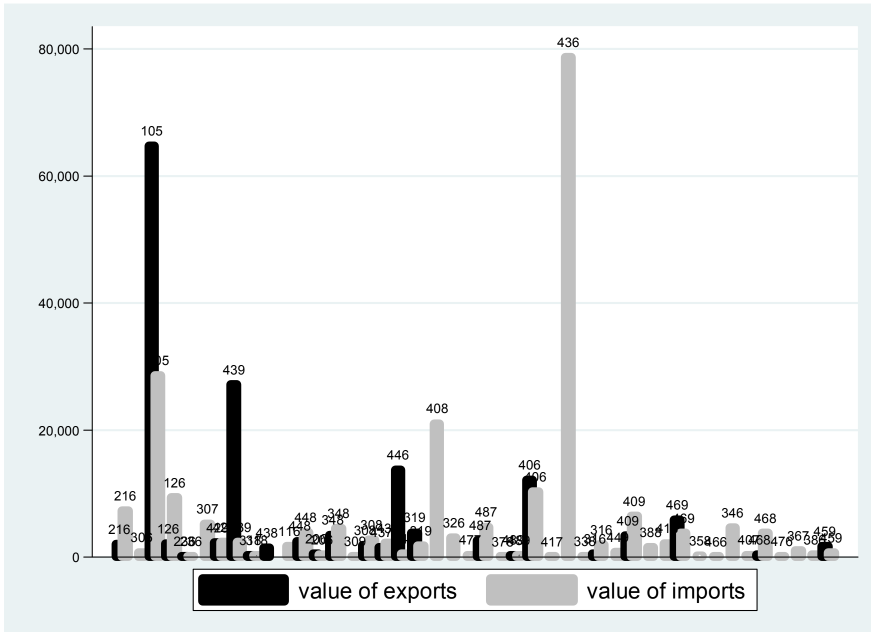


Notes: Authors' calculations are based on data from US 1940 census. See the text for the description of educational attainment and average wages.

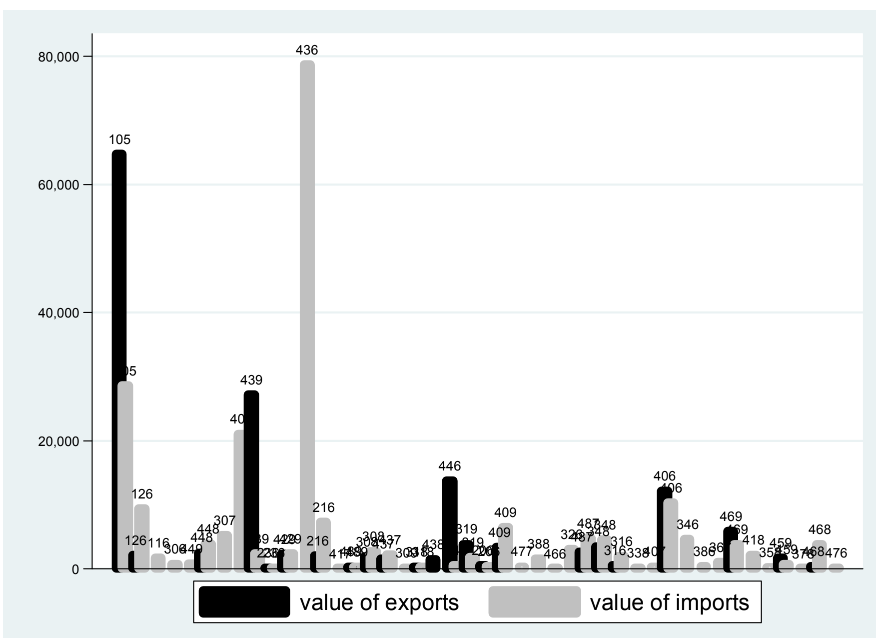
Figure 6. Value of Exports and Imports by Skill Intensity, 1903

Panel A: classified by educational attainment

Unit: thousand Haikwan Tael



Panel B: classified by log wage
Unit: thousand Haikwan Tael

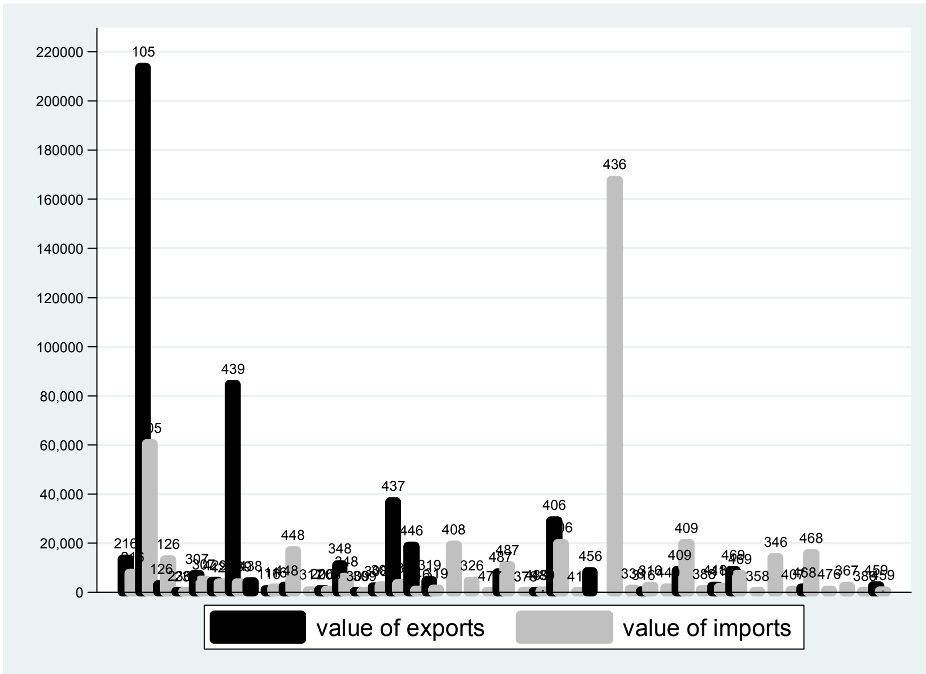


Source: Authors' calculation as described in the text. Numbers on individual bars correspond to industry codes listed in Tables 1 and 2.

Figure 7. Value of Exports and Imports by Skill Intensity, 1913

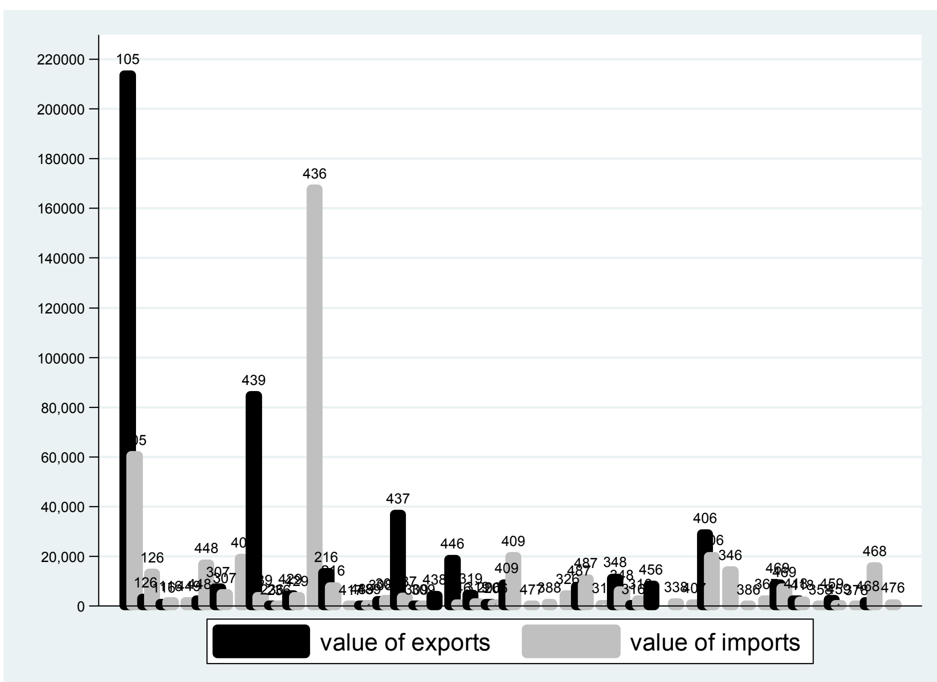
Panel A: classified by educational attainment

Unit: thousand Haikwan Tael



Panel B: classified by log wage

Unit: thousand Haikwan Tael

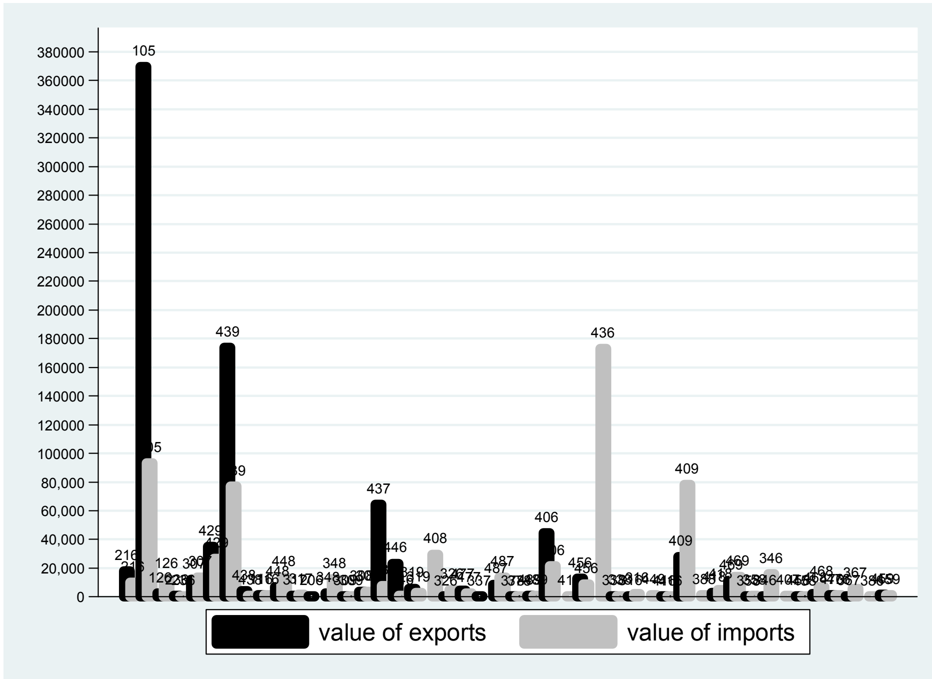


Source: Authors' calculation as described in the text. Numbers on individual bars correspond to industry codes listed in Tables 1 and 2.

Figure 8. Value of Exports and Imports by Skill Intensity, 1919

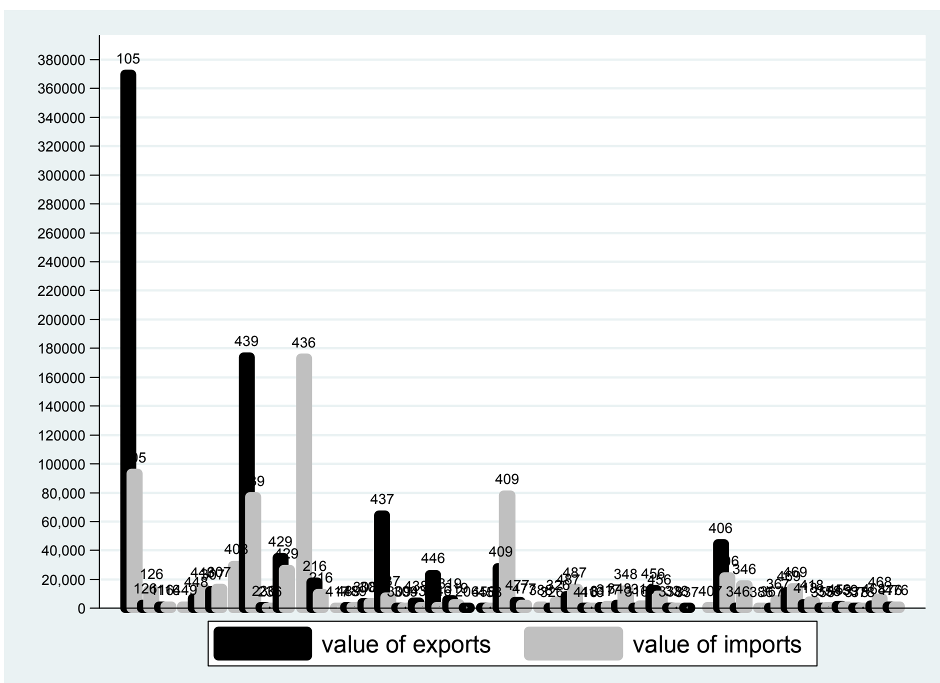
Panel A: classified by educational attainment

Unit: thousand Haikwan Tael



Panel B: classified by log wage

Unit: thousand Haikwan Tael

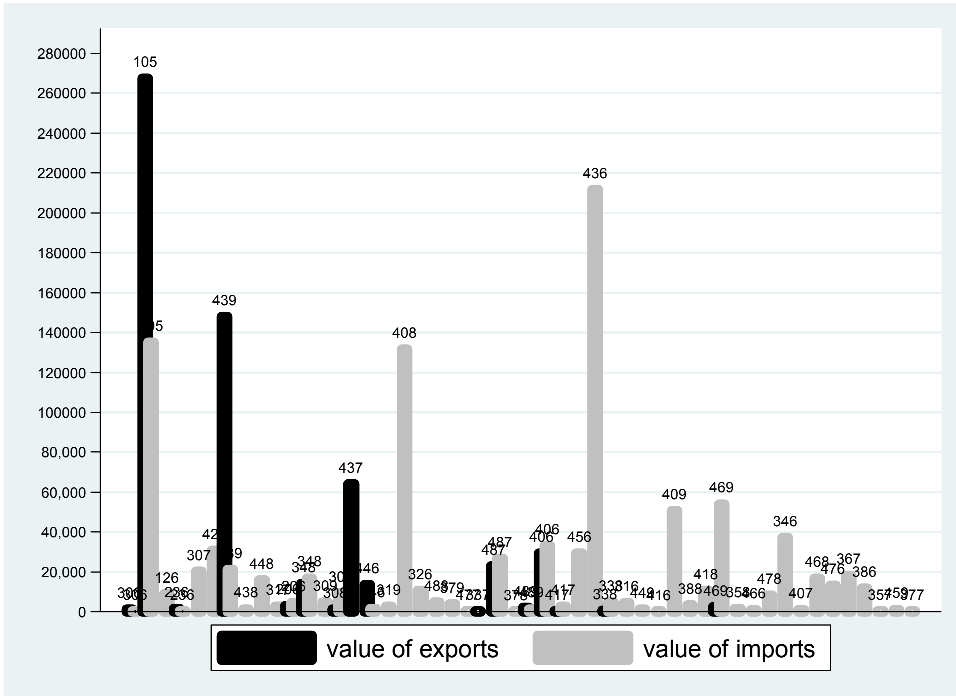


Source: Authors' calculation as described in the text. Numbers on individual bars correspond to industry codes listed in Tables 1 and 2.

Figure 9. Value of Exports and Imports by Skill Intensity, 1928

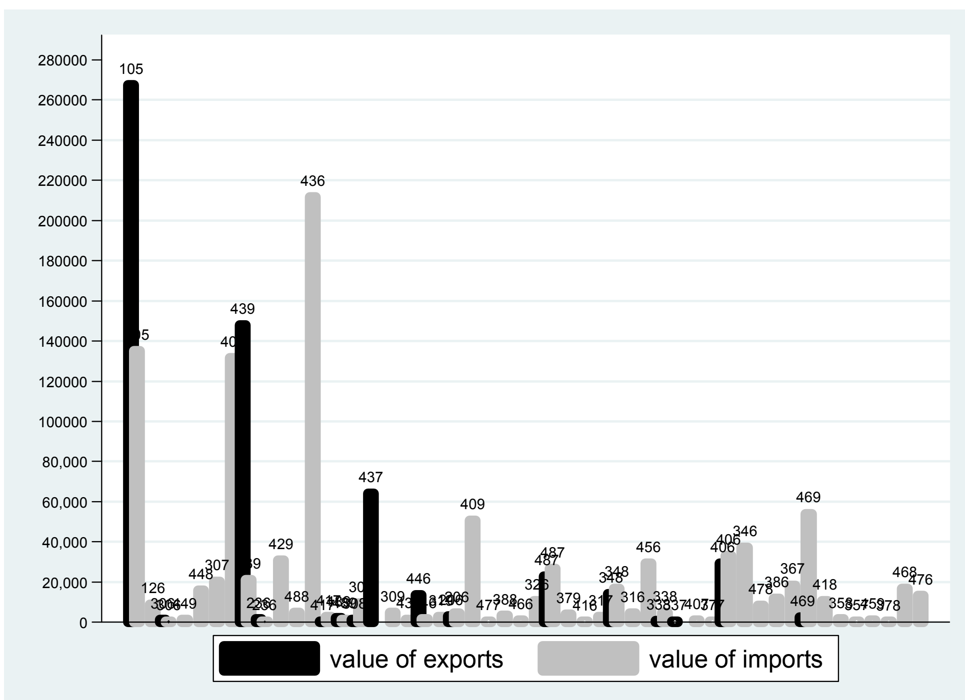
Panel A: classified by educational attainment

Unit: thousand Haikwan Tael



Panel B: classified by log wage

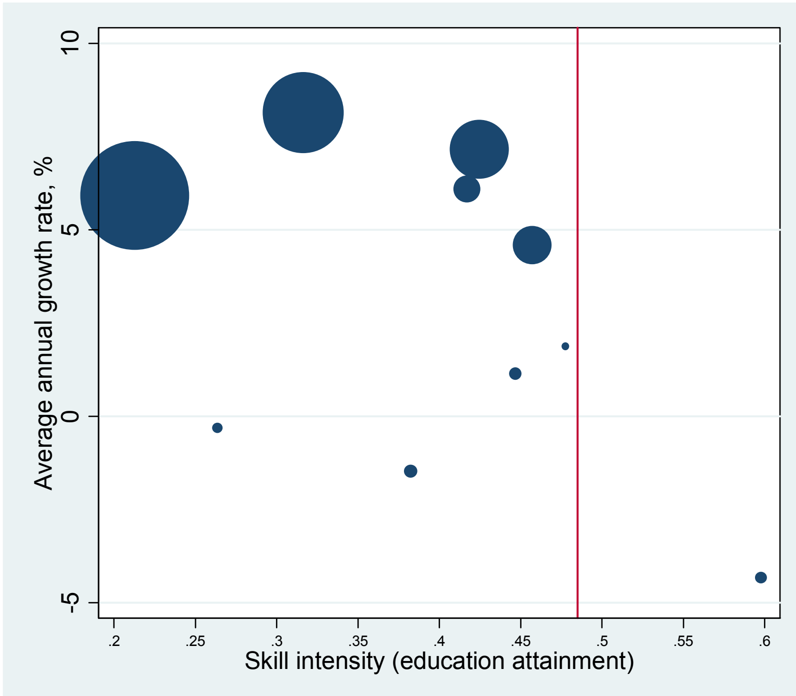
Unit: thousand Haikwan Tael



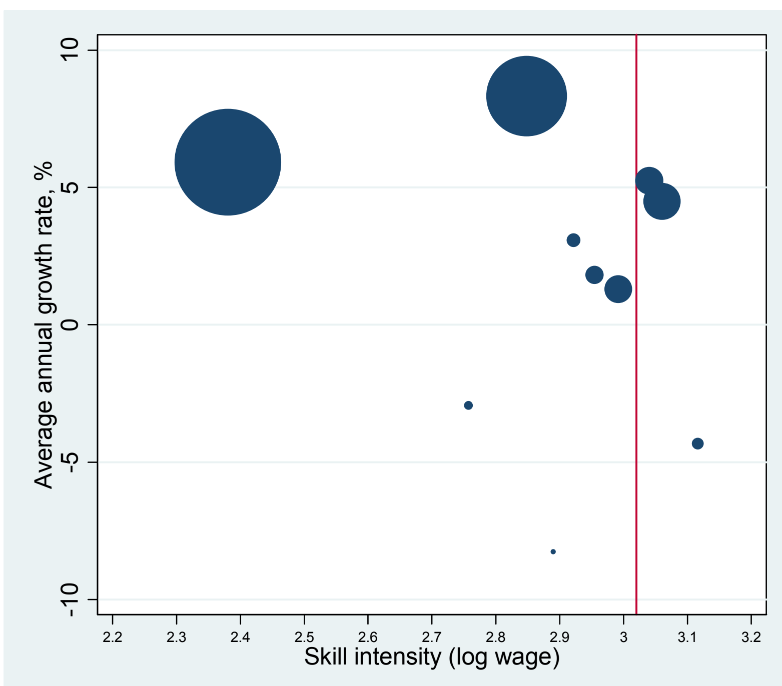
Source: Authors' calculation as described in the text. Numbers on individual bars correspond to industry codes listed in Tables 1 and 2.

Figure 10. Skill Intensity and the Growth Rate of Exports from 1903 to 1928

Panel A: classified by educational attainment



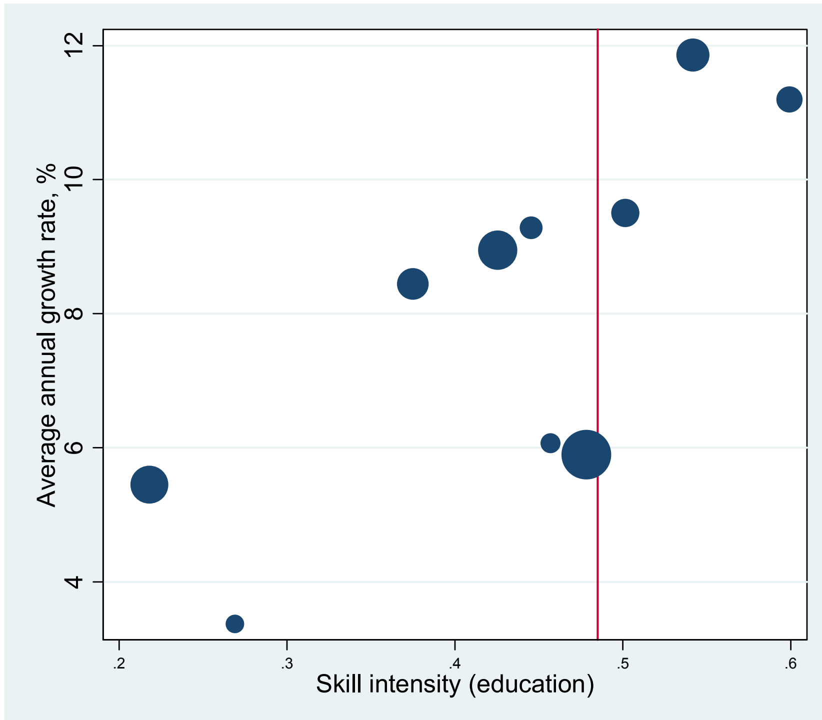
Panel B: classified by log wage



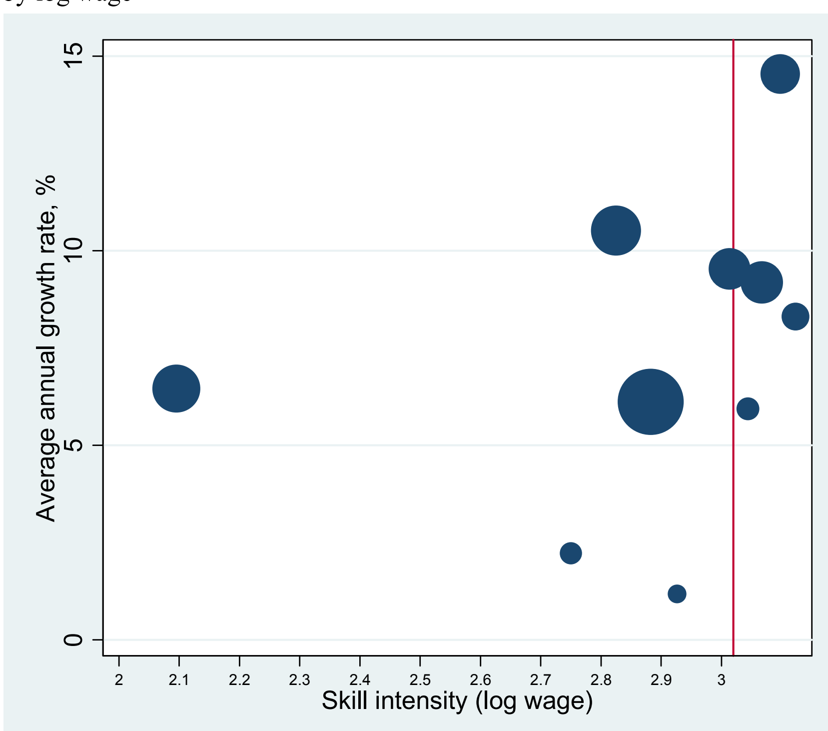
Source: Authors' calculation as described in the text. Skill intensity based on data from the 1940 US census.

Figure 11. Skill Intensity and the Growth Rate of Imports from 1903 to 1928

Panel A: classified by educational attainment

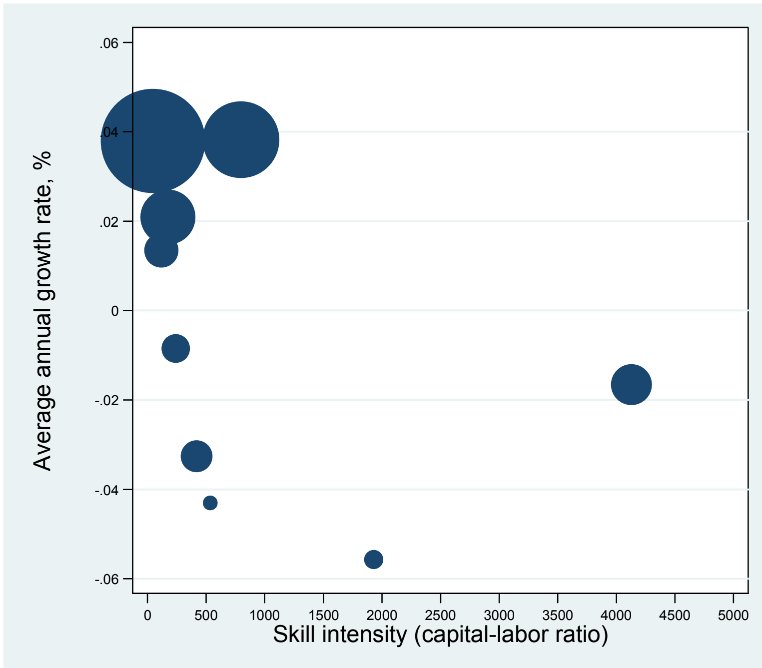


Panel B: classified by log wage



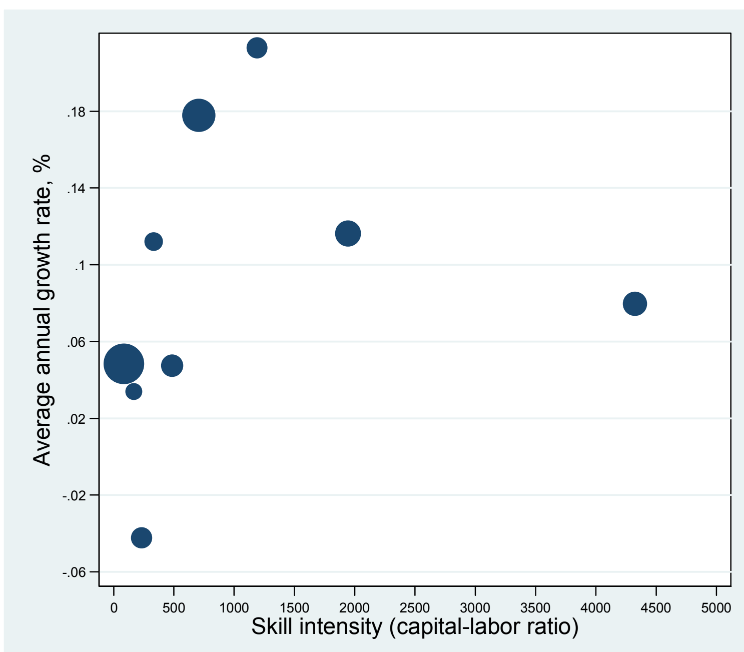
Source: Authors' calculation as described in the text. Skill intensity based on data from the 1940 US census.

Figure 12. Skill Intensity and the Growth Rate of Exports from 1903 to 1928



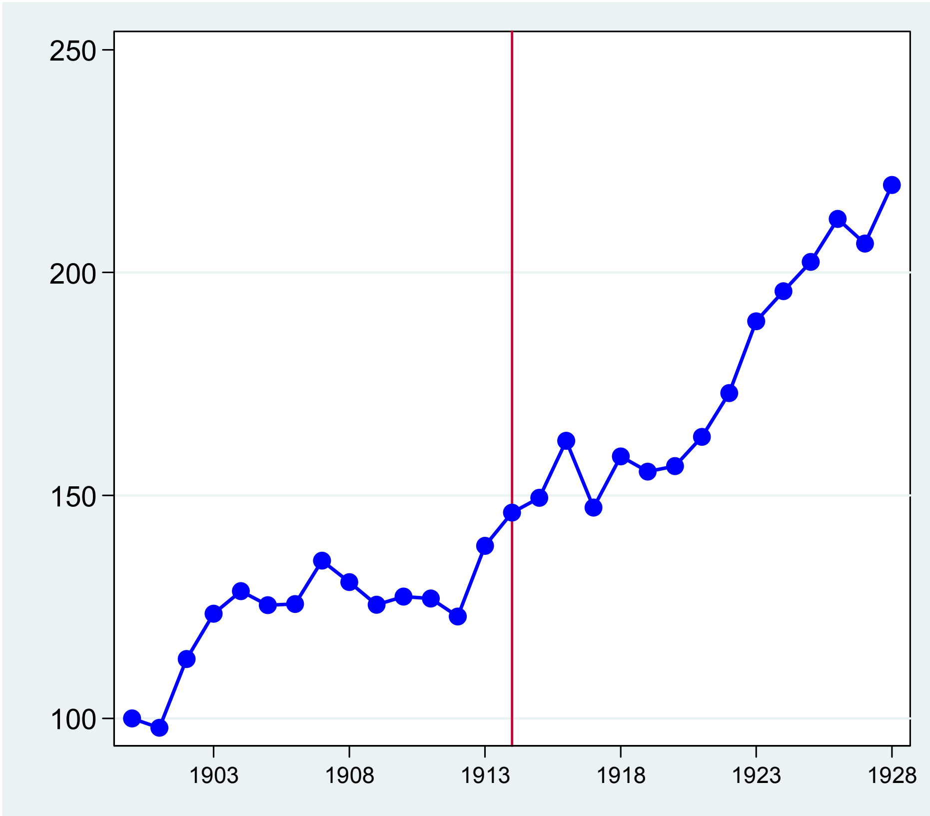
Source: Authors' calculation as described in the text. Skill intensity based on data from the 1928 Shanghai Survey

Figure 13. Skill Intensity and the Growth Rate of Imports from 1903 to 1928



Source: Authors' calculation as described in the text. Skill intensity based on data from the 1928 Shanghai Survey.

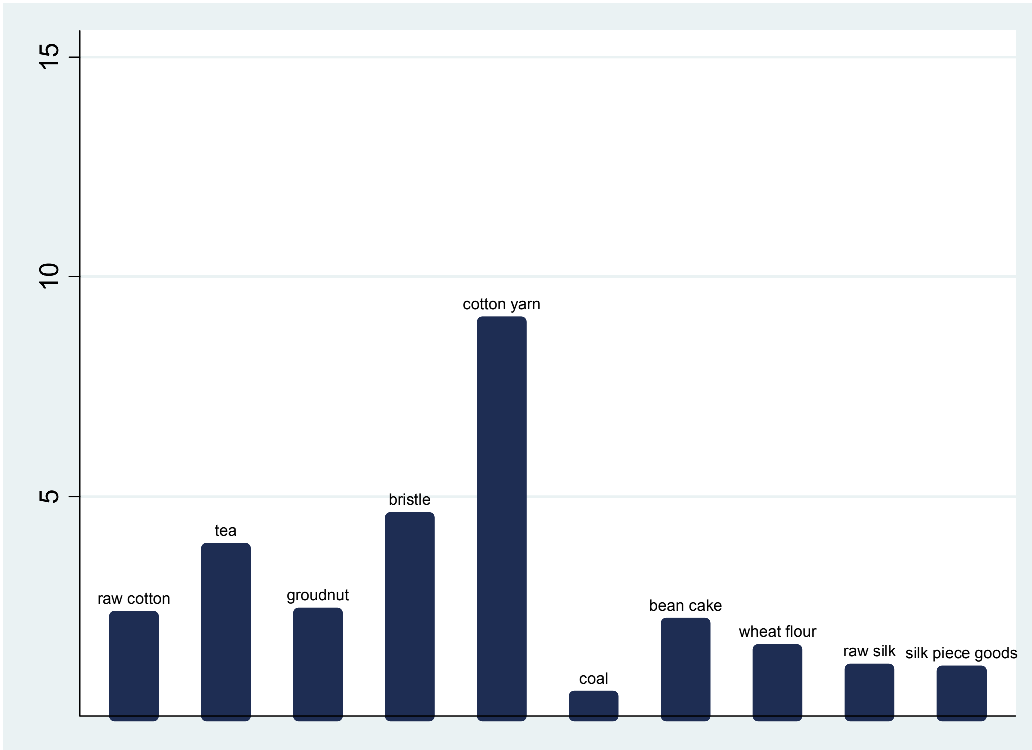
Figure 14. Price Index of Chinese Exports, 1903 to 1928



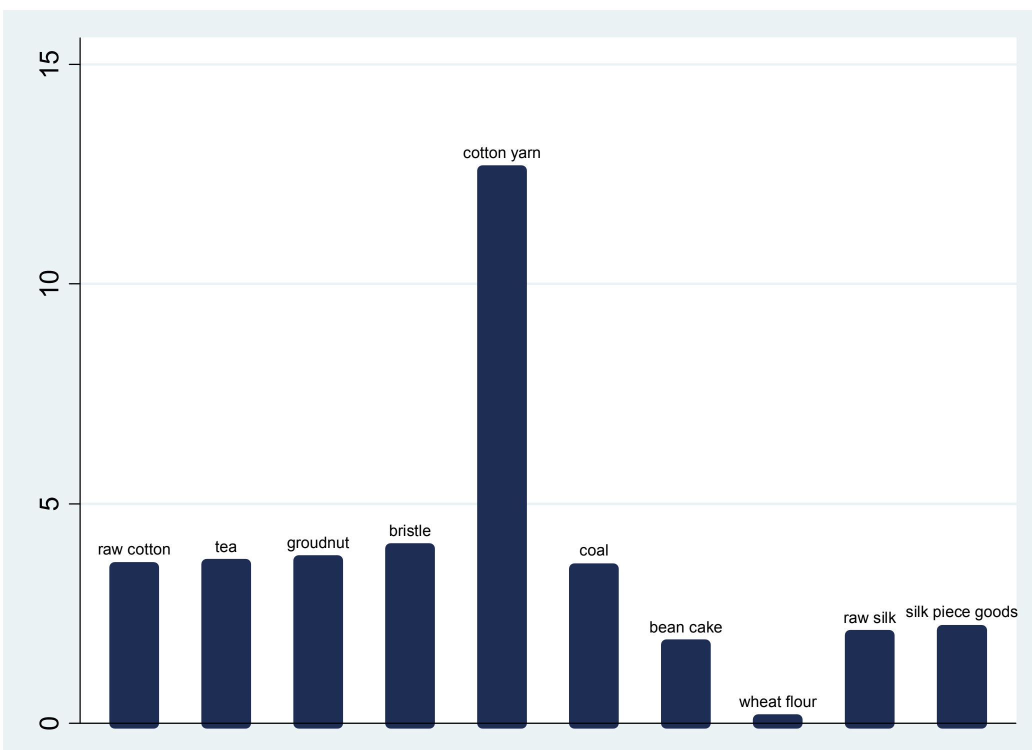
Source: Hsiao (1974)

Figure 15. Annual Percentage Growth Rates for Prices of Major Export Commodities

Panel A. 1903 to 1928



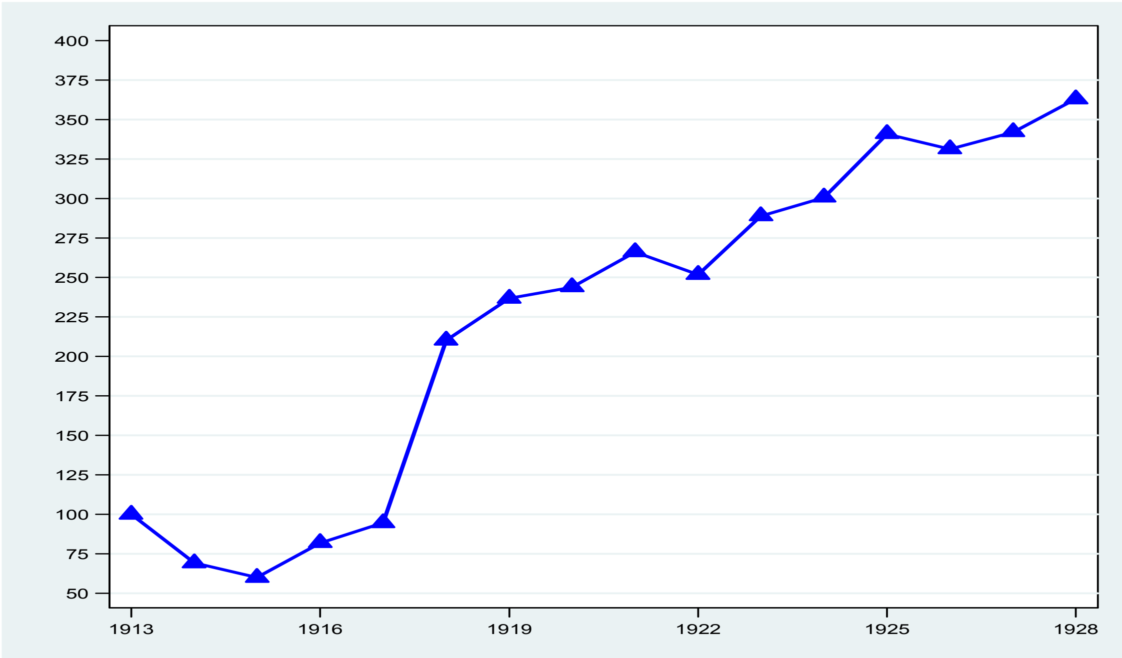
Panel B. 1914 to 1928



Source: Authors' calculations using data from the CMC's annual trade publications

Figure 16. Export Price of Cotton Yarn

Index of unit value: 1913=100



Source: CMC annual trade publications.

Figure 17. Simulation of the Skill Premium